ONTARIO DRINKING WATER OBJECTIVES

REVISED, 1994

Ontario

Ministry of Environment
and Energy

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PREAMBLE

This is the fifth edition of the Ontario Drinking Water Objectives. Approved by the Ontario Water Resources Commission on February 27, 1964, revisions were published in 1968, 1976, 1978 and 1983. The document is continually under review; amendments are consolidated and integrated into successive revisions.

The Federal-Provincial Subcommittee on Drinking Water has the responsibility for developing the Guidelines for Canadian Drinking Water Quality. This subcommittee is made up of representatives from each of the Canadian Provinces and Territories, Environment Canada, and Health Canada. It was established in 1986 by the Federal/Provincial Advisory Committee on Environmental and Occupational Health. The Conference of Deputy Ministers of Health approve all guidelines.

While most of the objectives listed are adopted from the Canadian Drinking Water Guidelines, the Province of Ontario has set some unique aesthetic objectives for colour, dissolved organic carbon, sulphates and methane. Health related objectives unique to Ontario have been set for total dioxin plus furan, polychlorinated biphenyls (PCB) and N-nitrosodimethylamine (NDMA). In this edition there are 44 new objectives for organic compounds of which 26 are pesticides.

The provision of a satisfactory supply of drinking water is to a large extent dependent upon the availability of sufficient quantities of high quality source water. While virtually any source water can, by treatment, be made suitable for drinking purposes, generally the more contaminated the supply the greater the treatment costs.

Provisions for the protection and enhancement of ambient water quality are outlined in the document entitled "Water Management"[1]. This publication and the Ontario Drinking Water Objectives are companion documents -the former containing **ambient water quality objectives**, the latter **treated drinking water objectives**. Care should be taken not to confuse the two.

[1]Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment; November 1978 revised May 1984.

AGLB copy 2

LEGISLATIVE RESPONSIBILITY

Each province has jurisdiction over its own water supplies. In Ontario, the Ontario Water Resources Act (OWRA) is the legislation that governs communal water systems. Private operators of water supply systems falling under the OWRA are also responsible for the quality of water at the consumer's tap. Water supplies not governed by the OWRA are the responsibility of local health agencies. Sections 75 to 79 of the OWRA pertain to plumbing and are administered by the Ontario Ministry of Housing. The Ontario Drinking Water Objectives are administered through the Ministry of Environment and Energy (MOEE) Policy #15-06 and are included in Policy #15-14 for supplies using surface water and #15-15 for supplies using ground water.

Approvals Branch of the MOEE, through the granting of Certificates of Approval, specifies monitoring requirements based on recommendations contained in the Ontario Drinking Water Objectives document. Regional staff of the MOEE are responsible for enforcing these monitoring requirements at all water supply systems (ministry, municipal or privately operated).

The MOEE solicits advice from medical experts at the Ministry of Labour, Ministry of Health, and Health Canada. Regional staff of the MOEE co-operate with local Medical Officers of Health in controlling potential health problems associated with community water supplies. The Medical Officer of Health, through the Health Protection and Promotion Act (Chapter 10, Part 3, Section 10,11,12 and 13), has the authority to judge whether water is safe for human consumption.

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1. ONTARIO DRINKING WATER OBJECTIVES

1.1 Introduction

The primary purpose of Drinking Water Objectives is to protect public health. Water intended for human consumption should not contain disease-causing organisms or hazardous concentrations of toxic chemicals or radioactive parameters. Water should be aesthetically acceptable. Taste, odour, turbidity and colour are parameters that, when controlled, result in water which is clear, colourless and without objectionable or unpleasant taste. Other aspects of water quality such as corrosiveness, tendency to form incrustations and excessive soap consumption should be controlled on the basis of economic considerations because of their effects on the distribution system and/or the intended domestic and industrial use of the water .

Parameters and their associated objectives are listed alphabetically in Tables 1 through 4. A brief description is provided for each parameter in Appendix A. Some parameters which do not have specific objectives are listed because there is an ideal range for them in terms of water treatment, plant operation or aesthetic water quality.

One section is devoted to sampling protocol, examination of drinking water supplies, and the recommended corrective actions to be taken when an objective level is exceeded. A summary of water disinfection procedures is outlined in Appendix B.

1.2 Types of Objectives

Objectives are considered to be the minimum level of quality and in no way should be regarded as implying that degradation of a high quality supply to the specified level is acceptable. The Drinking Water Objectives described herein have been derived from the best information currently available. The development of drinking water objectives, however, is a continual process. The understanding of the complex inter-relationships that determine water quality and the physiological effects of parameters present in water continues to grow. Society continues to introduce new chemicals into the environment that have a potential to contaminate drinking water supplies. Objectives are reviewed as new and more significant data becomes available. Criteria used to evaluate the safety of drinking water are continually reassessed as new con-

stituents are identified and health effects research advances. The water supply industry is developing new and improved operation and treatment techniques to respond to the changing criteria. Drinking water quality criteria must consider all factors that affect the quality of water, the public health significance of the constituents, and the available technology to treat water.

Almost all objectives are based on a 70 kg person consuming 1.5 litres of water per day for 70 years.

The following objectives shall be recognized:

Maximum Acceptable Concentration (MAC)

The MAC is a health-related objective established for parameters which when present above a certain concentration have known or suspected adverse health effects. The length of time the MAC can be exceeded without injury to health will depend on the nature and concentration of the contaminant. In the event that an MAC is exceeded in drinking water the local Medical Officer of Health (MOH) must be notified. Ultimate judgements regarding human health issues are made by the local MOH under the legislation of the Health Promotion and Protection Act.

Interim Maximum Acceptable Concentration (IMAC)

The IMAC is a health-related objective established for parameters when there is insufficient toxicological data to establish a MAC with reasonable certainty. When it is not feasible for practical reasons to establish a MAC at a desired level, an interim objective may be established at an achievable level.

Aesthetic Objective (AO)

AOs are established for parameters which may impair the taste, smell or colour of water or which may interfere with good water quality control practices. For certain parameters, both aesthetic objectives and health-related MACs have been derived.

Operational Guidelines (OG)

OGs are established for parameters which need to be controlled to ensure efficient treatment and distribution of the water.

1.3 Application of Objectives

The objectives outlined in this document prescribe standards of quality for all drinking water supplies. In carrying out its responsibilities under section 52 OWRA, the MOEE applies the ODWOs in approving the establishment of any water works[1], or the extension of or change in any existing water works capable of supplying water at a rate greater than 50,000 litres per day or water works that supply water for domestic purposes and serve more than five private residences.

2. WATER WORKS

2.1 Source, Protection, Treatment and Operations

The water supply should be obtained from a source that is most likely to produce drinking water of a quality meeting the Ontario Drinking Water Objectives. The source chosen should be one which is least subject to municipal and industrial pollution, as well as other types of pollution resulting from human activities within the watershed. The continuous presence of a parameter at a level in excess of the MAC should be grounds for rejection of the water unless effective and economic treatment is available. Chemical parameters should not be present in a water supply above their AO values where other more suitable supplies are or can be made available at a reasonable cost.

Frequent surveys of impacts on the water source should be conducted by the purveyor of the water. Each survey should attempt to recognize all potential sources of pollution of the supply and make an assessment of their present and future importance. The manner and frequency of the survey and any program to eliminate the problem must be made in consultation with the regional staff of the MOEE.

Some natural purification occurs in surface waters as a result of dilution, storage, sunlight and associated physical and biological processes. With ground water, natural purification may occur by infiltration of the water through soil and percolation through underlying material. Effective treatment should be provided to ensure safety and consistency in the quality of all finished waters.

Minimum treatment of surface waters and ground waters are stated in MOEE Policies. Policy 15-14 states that all water works in the Province of Ontario which

[1] "water works" means any works for the collection, production, treatment, storage, supply and distribution of water, or any part of such works, but does not include plumbing or other works to which regulations made under clause 75 (3) (a) of the OWRA apply.

utilize surface waters, i.e. lakes, rivers, streams etc., as a source of raw water shall use treatment processes consisting of coagulation-flocculation, filtration and disinfection. Policy 15-15 states that all water works in the Province of Ontario which utilize ground waters as a source of raw water shall be provided with a treatment process consisting of disinfection. In some cases additional processes may be required to produce a water that consistently meets the requirements of these objectives. The following would protect public health:

— treatment processes that are appropriate for the source of supply;

— a treatment plant with adequate capacity, within established MOEE design guidelines, to meet maximum demands;

— a treatment plant designed, located and constructed to minimize the effects of pollution at the raw water intake and to prevent contamination or disruption of the supply during flooding;

— conscientious, well-trained and competent treatment plant personnel with qualifications commensurate with the responsibilities of the position.

Where it is considered that proper source protection exists and the source quality is such as to warrant a variance from the treatment requirements, exemptions from Policy 15-14 or 15-15 may be recommended on a case-by-case basis and in accordance with Ministry guidelines.

2.2 Approval of Water Supplies

Construction of new water works or alterations to existing works may proceed only after an Approval, under Section 52,OWRA, has been issued by the MOEE.

The decision for approval of water supplies may be based on:

— adequate quantity and satisfactory quality of the water source based on the objectives in Tables 1-4;

— adequate treatment facilities to consistently produce water that meets objectives, guidelines and requirements as set out in this document;

— adequate capacity to meet peak demands without development of low pressures in the distribution system that could result in health hazards;

— enforcement of requirements to prevent development of health hazards; and,

— other sound engineering principles.

2.3 Responsibility for Water Quality

In general, the municipality is responsible for the distribution of the treated water. Where there is a Public Utilities Commission that is responsible for the treatment and distribution of water, it acts as a statutory agent for the appropriate municipality, and the municipality therefore remains ultimately responsible for ensuring that a water of adequate quality is delivered to consumers.

Private owners of water supply systems falling under the OWRA (serving more than five residences or capable of supplying water at a rate of greater than 50,000 litres per day) are fully responsible for the quality of water delivered to the consumer.

Table 1 — Chemical/Physical Objectives - Health Related

PARAMETER	MAC (mg/L)	IMAC (mg/L)	AO (mg/L)
Alachlor		0.005	
Aldicarb	0.009		
Aldrin + Dieldrin	0.0007		
Arsenic		0.025	
Atrazine + N-dealkylated metabolites		0.005	
Azinphos-methyl	0.02		
Barium	1.0		
Bendiocarb	0.04		
Benzene	0.005		
Benzo(a)pyrene	0.00001		
Boron		5.0	
Bromoxynil		0.005	
Cadmium	0.005		
Carbaryl	0.09		
Carbofuran	0.09		
Carbon Tetrachloride	0.005		
Chlordane	0.007		
Chlorpyrifos	0.09		
Chromium	0.05		
Cyanazine		0.01	
Cyanide	0.2		
Diazinon	0.02		
Dicamba	0.12		
1,2-Dichlorobenzene	0.2		0.003

PARAMETER	MAC (mg/L)	IMAC (mg/L)	AO (mg/L)
1,4-Dichlorobenzene	0.005		0.001
Dichlorodiphenyltrichloroethane (DDT)+metabolites	0.03		
1,2-Dichloroethane		0.005	
Dichloromethane	0.05		
2,4-Dichlorophenol	0.9		0.0003
2,4-Dichlorophenoxy acetic acid (2,4-D)		0.1	
Diclofop-methyl	0.009		
Dimethoate		0.02	
Dinoseb	0.01		
Dioxin and Furan		0.000000015 a	
Diquat	0.07		
Diuron	0.15		
Fluoride	b		
Glyphosate		0.28	
Heptachlor + Heptachlor Epoxide	0.003		
Lead	0.01 c		
Lindane	0.004		
Malathion	0.19		
Mercury	0.001		
Methoxychlor	0.9		
Metolachlor		0.05	
Metribuzin	0.08		
Monochlorobenzene	0.08		0.03
Nitrate (as nitrogen)	10.0 d		
Nitrite (as nitrogen)	1.0 d		
Nitrate + Nitrite (as nitrogen)	10.0 d		
Nitrilotriacetic Acid (NTA)	0.4		
Nitrosodimethylamine (NDMA)		0.000009	
Paraquat		0.01	
Parathion	0.05		
Pentachlorophenol	0.06		0.03
Phorate		0.002	
Picloram		0.19	
Polychlorinated Biphenyls (PCB)		0.003	
Prometryne		0.001	

PARAMETER	MAC (mg/L)	IMAC (mg/L)	AO (mg/L)
Selenium	0.01		
Simazine		0.01	
Temephos		0.28	
Terbufos		0.001	
2,3,4,6-Tetrachlorophenol	0.10		0.001
Triallate	0.23		
Trichloroethylene	0.05		
2,4,6-Trichlorophenol	0.005		0.002
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.28		0.02
Trifluralin		0.045	
Trihalomethanes	e		
Turbidity	f		f
Uranium	0.10		
Vinyl Chloride	0.002		

Notes on Table 1:

Shortforms:

MAC – Maximum Acceptable Concentration
IMAC – Interim Maximum Acceptable Concentration
AO – Aesthetic Objective
NTU – Nephelometric Turbidity Unit
mg/L – milligrams per litre
pg/L – picograms per litre

Footnotes:

a) Total toxic equivalents when compared with 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin)

b) Where fluoridation of drinking water is practised, it is recommended that the concentration be adjusted to 1.0 (+/- 0.2) mg/L, the optimum level for control of dental caries. Communities in Northern Ontario, where the annual mean daily maximum temperature is less than 10 °C may wish to consider adjusting the fluoride concentration to 1.2 (+/- 0.2) mg/L. Adverse effects of fluoride in drinking water above 1.5 mg/L and below 2.4 mg/L are cosmetic in nature (dental mottling in a small proportion of the population). Levels above 1.5 mg/L should be reported to the local medical officer of health.

c) This objective applies to water at the point of consumption. Since lead is a component in some plumbing systems, first flush water may contain higher concentrations of lead than water that has been flushed for five minutes. Faucets, therefore, should be thoroughly flushed before water is taken for consumption.

d) Where nitrate and nitrite are present, the total of the two should not exceed 10 mg/L.

e) The MAC of 350 µg/L for trihalomethanes in drinking water is currently under review.

f) A MAC for turbidity of 1 NTU in drinking water leaving the treatment plant was established to ensure the efficiency of the disinfection process. Treatment processes can result in increased turbidity in the distribution system. To ensure that the aesthetic quality is not degraded, an aesthetic objective for turbidity at the free flowing outlet of the ultimate consumer has been set at 5 NTU.

Table 2 — Microbiological Objectives - Health Related

PARAMETER	MAC (per 100 mL)
Total Coliforms	see (a) below
Escherichia coli and/or Fecal Coliforms*	not detected
General Bacterial Population	**

Where one of the following occurs:

a) Total coliform bacteria are detected in consecutive samples from the same site or in multiple samples taken as a single submission from a distribution system;

b) *Escherichia coli* (*E. coli*) and/or fecal coliform are detected in any distribution sample.

the water is considered to be unsafe and the MOEE district officer must be notified immediately. They in turn will immediately notify the Medical Officer of Health and instruct the operating authority to take special samples and/or corrective action.

The corrective action includes immediately increasing the disinfection dose and flushing the mains to ensure a total chlorine residual of at least 1.0 mg/L or a free chlorine residual of 0.2 mg/L to all points in the affected part(s) of the distribution system. Corrective action outlined should begin immediately and continue until the objectives are no longer exceeded in two consecutive sets of samples.

Footnotes:

* *Escherichia coli* is a more definitive indicator of fecal contamination than other fecal coliforms or total coliforms.

** At elevated levels, the general bacterial population may interfere with the detection of coliforms. This general population can be estimated from either background colony counts on the total coliform membrane filters or heterotrophic plate counts (HPC). If the membrane filter contains more than 200 background colonies on a total coliform medium per 100 mL or if the HPC exceeds 500 colonies per mL, the site should be resampled. If there is a recurrence of unacceptable background or heterotrophic plate counts, an inspection of the site should be undertaken to determine the cause.

Table 3 — Radionuclide Objectives - Health Related

PARAMETER	MAC (Bq/L)
Cesium-137	50
Iodine-131	10
Radium-226	1
Strontium-90	10
Tritium	under review

Notes on Table 3:

Radionuclide concentrations that exceed the MAC may be tolerated for a short duration, provided that the annual average concentrations remain below the MAC and the restriction (see immediately below) for multiple radionuclides is met.

Restrictions for multiple radionuclides - If two or more radionuclides affecting the same organ or tissue are present, the following relationship based on International Commission on Radiological Protection(ICRP) Publication 26, should be satisfied:

$$\frac{c_1}{C_1} + \frac{c_2}{C_2} + \ldots\ldots\ldots\ldots\ldots + \frac{c_i}{C_i} \leq 1$$

where c_1, c_2, and c_i are the observed concentrations, and C_1, C_2, and C_i are the maximum acceptable concentrations for each contributing radionuclide.

Table 4 — Chemical/Physical Objectives - Not Health Related

PARAMETER	OBJECTIVE (mg/L - unless otherwise specified)	TYPE OF OBJECTIVE
Alkalinity (as $CaCO_3$)	30-500	OG
Aluminum	0.10	OG
Chloride	250	AO
Colour	5 TCU	AO
Copper	1.0	AO
Dissolved Organic Carbon	5.0	AO
Ethylbenzene	0.0024	AO
Hardness (as $CaCO_3$)	80-100	OG
Iron	0.30	AO
Manganese	0.05	AO
Methane	$3L/m^3$	AO
Odour	Inoffensive	AO
Organic Nitrogen	0.15	OG
pH	6.5-8.5 (no units)	OG
Sodium	a	AO
Sulphate	500[b]	AO
Sulphide	0.05	AO
Taste	Inoffensive	AO
Temperature	15°C	AO
Toluene	0.024	AO
Total Dissolved Solids	500	AO
Xylenes	0.30	AO
Zinc	5.0	AO

Notes on Table 4:

Shortforms:

AO — Aesthetic objective   OG — Operational Guideline   TCU — True Colour Units

Footnotes:

a) The aesthetic objective for sodium in drinking water is 200 mg/L. The Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be disseminated to local physicians for their use with patients on sodium restricted diets.

b) When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.

3. WATER QUALITY CHARACTERISTICS

Parameters that contribute to the characteristics of water fall into one of two categories, health or aesthetic. Health related parameters are a concern for acute and/or chronic exposure, whereas parameters that affect taste and odour, or which cause operational problems are aesthetic. Parameters affecting the quality of water can be characterised as microbiological, chemical, physical or radiological. The objectives for health related parameters, chemical or physical, are listed in Table 1, microbiological objectives are listed in Table 2 and objectives for radionuclides are listed in Table 3. Aesthetic objectives are listed in both Tables 1 and 4. Each parameter is discussed in Appendix A.

3.1 Health-related Characteristics

3.1.1 Microbiological Characteristics

Microbiological quality of drinking water is the most important aspect of drinking water quality because of its association with waterborne diseases. Typhoid fever, cholera, enteroviral disease, bacillary and amoebic dysenteries, and many varieties of gastrointestinal diseases can all be transmitted by water. Objectives for viruses and protozoa are not proposed at this time, however, it is desirable that no virus or protozoa (eg. *Giardia*, *Cryptosporidium*) be present in a drinking water. The introduction of a well managed water treatment system with effective filtration and disinfection, maintenance of an adequate disinfectant residual and the implementation of bacteriological surveillance programs to ensure the delivery of safe drinking water have demonstrated effectiveness in eliminating water-related illness. Occasional outbreaks of waterborne diseases emphasize the continuing importance of strict supervision and control over the microbiological quality of drinking water supplies.

3.1.2 Chemical Characteristics

Certain chemicals are potentially toxic and may adversely affect human health. Heavy metals and ions such as cyanide, some commonly occurring organic compounds, and many less common organic and organometallic parameters are potentially hazardous in drinking water. It is desirable to control the intake of these potentially toxic chemicals from drinking water because the intake from other sources as milk, food, or air may be difficult to avoid. MACs have been set for those toxic chemical parameters that could be present at significant levels in drinking water. In general, total

environmental exposure and possible adverse effects from long-term exposure have been taken into consideration in deriving the objective. The aim of setting objectives for contaminants is to avoid undesirable health effects, however, fluoride is unique in that its presence at carefully controlled concentrations results in the beneficial health effect of reducing the incidence of dental caries.

Inorganic parameters may be present in the water naturally or as a result of industrial, urban, agricultural activities or other discharges.

Organic parameters are present to some degree in all municipal water supplies. Industrial and municipal waste, urban and rural run-off, and the natural decomposition of biological matter all contribute to the organic content. Some organic chemicals occur in water naturally as a result of organic decomposition. Synthetic organic chemicals can also occur in drinking water as a result of certain water treatment practices and/or direct contamination of the raw water from point and non-point sources of pollution. Most synthetic organic chemicals detected in drinking water are present at low concentrations and do not appear to pose a health threat. The majority, however, have not been fully examined for all potential health effects and as a matter of prudence concentrations of these chemicals should be as low as possible.

It is desirable that drinking water be free of pesticides, and every effort should be made to prevent pesticide pollution of raw water sources. Pesticides may be reported by their most common trade names, a listing of which is published annually in the Ontario Gazette.[1]

MACs have been derived for a variety of pesticides. Where possible, data concerning the proportion of total intake normally ingested in drinking water (based on mean levels in food, air and drinking water) or intake estimated on the basis of consideration of physical/chemical properties were used in the calculations. Where such information was unavailable, 20% was used in the derivation of the MAC. Therefore, daily consumption of 1.5 litres of water containing a specific pesticide at the level of the MAC would result in the ingestion of not more than 20% of the allowable daily intake for that pesticide. If a pesticide not listed in Table 1 is confirmed to be present as a result of a routine analytical scan, the appropriate health authority should be consulted.

[1] available from Publications Ontario Book Store, 880 bay St., Toronto M7A 1N8

3.1.3 Physical Characteristics

The physical characteristics of water traditionally include colour, odour, taste, temperature and turbidity. Although these are primarily aesthetic parameters, they can have indirect effects on health through interrelationships with health-related parameters. For example, temperature affects the rate of growth of micro-organisms, while some colour-producing and naturally occurring organic parameters are trihalomethane precursors. To date, turbidity is the only physical characteristic for which there are sufficient data to establish a limit on the basis of health considerations.

3.1.4 Radioactive Characteristics

There are more than 200 radionuclides. Some occur naturally while others are products from human activities such as nuclear energy production, nuclear weapons testing and manufacturing. Processes that use raw products contaminated with naturally occurring radionuclides and processes which inadvertently concentrate naturally occurring radionuclides are also anthropogenic sources.

Ingestion of radionuclides in drinking water may cause cancer in exposed individuals and heritable genetic changes in their progeny. The probability of inducing such effects is assumed to be proportional to the radiation doses delivered to sensitive organs and tissues. It is assumed that no threshold exists below which the probability of induced effects is zero.

In practice, MACs have been set for radionuclide concentrations in water to protect consumers of drinking water from unacceptable risks. In keeping with the philosophy of the International Commission on Radiological Protection (ICRP), levels should be as low as is reasonably achievable given the economic and social considerations, but should not exceed the MAC.

3.2 Aesthetic Characteristics and Other Considerations

The water quality characteristics discussed in this section do not directly affect the safety of a water supply but may cause aesthetically objectionable effects or render a water unsuitable for domestic use. The primary goal in setting objectives on the basis of aesthetic considerations is to produce a treated water that is pleasant to consumers. Compliance with these objectives may result in associated health benefits. Pleasing aesthetic qualities will promote consumer confidence in municipal supplies and discourage the use of unregulated water sources.

Aesthetic objectives (AO) have been derived for a number of chemical and physical characteristics that affect the aesthetic quality of drinking water or interfere with good water quality control practices. The existence of guidelines as defined above should not be regarded as implying that the quality of the drinking water may be degraded to the specified levels. Indeed, a continuous effort should be made to promote the highest possible quality in drinking water. An aesthetic objective should not be exceeded when more suitable supplies are, or can be made available at a reasonable cost.

3.2.1 Microbiological Characteristics

Several species of algae, protozoa and other micro-organisms can cause problems such as unpleasant taste and clogged filters. Iron bacteria can cause discolouration, turbidity and taste problems or form slime and iron oxide accumulations in pipes, thus reducing the capacity of the system. Sulphate reducing bacteria can contribute to corrosion of water mains and to taste and odour problems. Macro-organisms such as Nematodes, which may not pose a direct health risk, may harbour pathogenic viruses and bacteria and shield them from disinfectants.

Microbiological examination of drinking water is of value in determining the cause of objectionable tastes and odours and clogging of distribution pipes and filters. Since most of these organisms are removed by conventional treatment, these problems are more likely to occur in supplies where flocculation and filtration are not practised. Nuisance organisms are particularly difficult to control once they become established within the distribution system. Many are resistant to the disinfecting action of chlorine or may be protected by debris and slime. It is difficult, however, to specify any quantitative limit on these organisms because individual species differ widely in their ability to produce undesirable effects. Many of the problems caused by nuisance organisms are covered by the objectives on the physical characteristics of water.

The population of organisms within a water supply system can be controlled by reducing nutrients entering the system, eliminating entry of invertebrates, and keeping the distribution system clean. This can be achieved by efficient treatment allowing only low turbidity water to enter the system, covering reservoirs, maintaining a chlorine residual, systematically cleaning the distribution system by flushing and if necessary, foam swabbing, and applying good practices when repairing or replacing old mains or preparing new mains for service. The elimination of dead ends will remove locations or sources of infestations.

3.2.2 Chemical Characteristics

The chemical parameters discussed may be aesthetically objectionable, interfere with water treatment processes and distribution system, or stain fixtures and plumbing. Colour and taste and odour problems tend to be associated with high levels of organic matter. Numerous individual organics may be responsible and therefore, it is not usually practical to set objectives for specific parameters.

3.2.3 Physical Characteristics

Physical characteristics provide what is probably the oldest method of judging water quality. The acceptability of drinking water to consumers still depends to a large degree on colour, clarity, taste, odour and temperature. Certain physical characteristics may also interfere with treatment processes resulting in increased operating costs.

An important consideration in discussing physical characteristics is the effect on other water quality parameters. Colour for example, may be related to the presence of iron or manganese. Temperature affects taste and odour perceptions. Corrosion and incrustations, which in turn affect colour and taste and odour, can be directly related to pH. Controlling the physical characteristics can result in overall improvement to drinking water quality.

4. SAMPLING, ANALYSIS AND CORRECTIVE ACTION

Samples are taken from water supply systems primarily to determine whether the water is safe for human consumption. These samples must therefore be representative of the supply as a whole. If samples are carelessly collected or taken from locations that are not representative of the whole system, then the purpose of sampling is defeated. Unrepresentative sampling may even be dangerous because it can give rise to unjustified confidence in the quality of water. It may also cause unnecessary cost and concern. The health significance of a parameter, the degree to which its concentration varies over time, in conjunction with other factors affecting it and the population at risk, should be considered in determining the sampling frequency.

It is important to note that a single sample is of limited value. The most a single sample can show is the water quality at the time of sampling. Therefore, it is necessary that repeat samplings be performed and complete records be maintained in order to get an adequate picture of the conditions in the water supply. The use of standard analytical techniques also allows for valid comparison of data collected in different places at various times and identification of trends in water quality. The

availability of reliable, up-to-date, comprehensive information on contaminants to which the public may be exposed is essential for establishing new objectives or revising the current ones.

Analytical (microbiological, chemical, physical etc.) methods are available from the MOEE[1]. Similarly, microbiological methods are also available from the MOH.[2] Analytical methods for radionuclides are available from the Ministry of Labour[3]. Where such methods are not suitable because of scale or equipment limitations, the methods used should be as prescribed in the current edition of "Standard Methods for the Examination of Water and Wastewater".[4] All samples must be analyzed by methods and laboratories acceptable to the MOEE and the results must be assembled and made available for inspection by the MOEE. The Ministry of Health also conducts microbiological analysis in response to public health concerns and is the agency responsible for microbiological analysis of private supplies.

Most of the parameters set forth in these objectives can be routinely analyzed in the laboratory, while a few are best determined in the field. Routine analytical methods are developed such that results will be generated for a group of parameters from one single aliquot thereby reducing the volume of sample necessary. Routine analytical methods for several parameters have yet to be developed, therefore analysis for those parameters will only be conducted in response to specific situations after discussion with laboratory staff.

Details concerning the proper collection, preservation and shipment of samples, plus a listing of the analytical capabilities of the various regional MOEE Laboratories are contained in the publication "**A Guide to the Collection and Submission of Samples for Laboratory Analysis**"[1]. Appropriate sampling guidelines for the submission of samples to the Ministry of Health Laboratories are described in "The Guide to the Collection and Submission of Samples"[2] and details of the proper sampling procedures are provided in the "Health Inspectors Guide to the Principles and Practices of Environmental Bacteriology".[2]

[1] Available from Laboratory Services Branch, MOEE, 125 Resources Road, Etobicoke, Ontario M9P 3V6

[2] Available from Laboratory Services Branch, MOH, Box 9000 Terminal 'A', Toronto, Ontario M5W.1R5

[3] Available from Radiation Protection Service, MOL, 81 Resources Road, Weston, Ontario M9P 3T1

[4] American Public Health Association/American Water Works Association/Water Pollution Control Federation, available from APHA, Washington, D.C., USA.

4.1 Microbiological Organisms

Contamination by sewage or excrement presents the greatest danger to public health associated with drinking water, and microbiological testing provides the most sensitive means for the detection of such pollution. Contamination is often intermittent and may not be revealed by the examination of a single sample. Proper supervision of a water supply is usually based on results of multiple microbiological samples.

4.1.1 Frequency and Location of Sampling and Analysis

Sampling frequency and location should be sufficient to maintain proper supervision of the water supply's microbiological quality. Frequency of analyses and location of sampling points shall be established by the operating authority under the direction of the MOEE after investigation of the source, including source protection protocol and method of treatment. Samples shall not necessarily be taken from the same points on each occasion. All samples in a given submission must be tested for total coliforms as well as *Escherichia coli* and/or fecal coliforms. In addition, a minimum of 25% must be analyzed for heterotrophic plate count or background colonies on a total coliform membrane filter medium. All samples where no chlorine residual is detected must be analyzed for heterotrophic plate count.

In systems treating surface or ground water, samples should be taken from the raw water source and from the point at which treated water enters the distribution system. In these systems sampling should be at least weekly in systems serving populations up to 100,000 and more often in larger systems. In addition, the operator **must** ensure that the disinfection process is functioning properly at all times. In ground water systems that only disinfect, water samples shall be taken and examined not less than once per week from the source and all points at which water enters the distribution system.

The number of microbiological samples to be collected and the frequency of sampling from a distribution system shall be determined by the Certificate of Approval. In the event that a Certificate of Approval has not been issued, the following outlines the minimum sampling requirements:

Table 5 — Distribution System Sampling Requirements

Population Served	Minimum Number of Samples Per Month	Minimum Frequency of Sampling
Up to 100,000	8 + 1 per 1,000 population	Weekly
Over 100,000	100 + 1 per 10,000 population	Several times per week

When a municipality or other operating authority begins experiencing adverse microbiological water quality from any of the sampling sites, a sampling program as outlined in Section 4.1.3 (Assessment and Corrective Action) must be undertaken. Samples from such a program should be considered additional to the requirements tabled above.

4.1.2 Indicators of Unsafe Drinking Water Quality

If any of the following conditions exist, the drinking water is judged **unsafe**:

- ***Escherichia coli*** and/or fecal coliforms are detected in any distribution sample by any analytical method;
- Total coliforms are detected in consecutive samples from the same site or in multiple samples taken as a single submission from a distribution system.
- In communal drinking water supplies, more than 10 % of the samples (based on a minimum of 10 samples per month) show the presence of coliform organisms.

4.1.3 Assessment and Corrective Action when a Microbiological MAC is Exceeded

In general, the type of coliform organism in a water sample and the number of samples that contain these bacteria are an indication of the degree of bacterial contamination that exists in a distribution system. Results may represent either highly localized contamination or diffuse contamination throughout the distribution system. The response to adverse results may, therefore, differ according to the severity of the problem.

If the water contains any indicators of unsafe water quality for any of the reasons outlined above, the laboratory will immediately notify the MOEE District Officer who will immediately notify the Medical Officer of Health and the operating authority to initiate collection of **special samples** and/or take corrective action.

The corrective action includes immediately increasing the disinfection dose and flushing the mains to ensure a total chlorine residual of at least 1.0 mg/L or a free chlorine residual of 0.2 mg/L to all points in the affected part(s) of the distribution system. Corrective action outlined should begin immediately and continue until the objectives are no longer exceeded in two consecutive sets of samples.

If satisfactory chlorine or disinfectant residuals are not detected in the affected part(s) of the distribution system or if the circumstances warrant, a **Boil Water Advisory** may be issued by the Medical Officer of Health. The corrective measures along with intensive resampling and analysis in the area of the affected parts or, at the discretion of the Medical Officer of Health, in the entire water system, should continue until the objectives are no longer exceeded in two consecutive sets of samples.

4.1.3.1 Special Sampling

Special sampling shall consist of a minimum of 3 samples to be collected for each positive sampling site: one sample should be collected at the affected site; one at an adjacent location on the same distribution line; and a third sample should be collected some distance upstream on a feeder line toward the water source. These samples must be marked "special" on the laboratory submission sheet. The chlorine residual and the time of sampling for each site must be noted on the laboratory submission sheet beside each sampling location. The collection of 3 special samples is considered the minimum number for each positive sampling site. The measurement of the chlorine residual in the vicinity of the positive sampling site may assist in determining the extent of the contamination within the distribution system, and may be used to determine the appropriate corrective action.

4.1.4 Indicators of Deteriorating Drinking Water Quality

Any of the following conditions indicate a deterioration in drinking water quality:

a) total coliforms detected as a single occurrence (but not *Escherichia coli* or other fecal coliforms);

b) samples contain more than 500 colonies per mL on a heterotrophic plate count analysis;

c) samples contain more than 200 background colonies on a total coliform membrane filter analysis;

d) *Aeromonas* spp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Clostridium* spp. or members of the Fecal Streptococcus *(Enterococcus)* group are detected.

If any of these conditions occur, the MOEE district officer should be notified so that an inspection of the sampling sites can be undertaken to determine the cause.

Special samples should be taken as indicated in 4.1.3.1, if these are positive then corrective action as outlined in 4.1.3 will be initiated.

4.2 Chemical and Physical Parameters

4.2.1 Sampling and Analysis

Examination of drinking water for chemical characteristics is not generally required as frequently as for microbiological control. The minimum frequency and location of sampling is normally specified by the MOEE on the Certificate of Approval. A minimum sampling program that may be followed to establish a quality database is suggested below. It should be borne in mind that the chemical quality of a water supply may change seasonally or in response to weather conditions and agricultural practices, spills etc., and in these cases sampling should be such as to provide adequate supervision of water quality to ensure that the health of the consumer is not being endangered. The following sub-sections provide guidance on the general monitoring provisions for surface water and ground water supplies in Ontario. All monitoring is to be from the point at which treated water enters the distribution system unless directed otherwise.

4.2.1.1 Surface Water Source Without Filtration

Water Supply Systems using surface water, or ground water under the direct influence of surface water and not performing filtration, should monitor -

i. turbidity levels, using a grab sample, every four hours or by continuous monitoring.

ii. disinfectant residual (equivalent to free chlorine) by continuous monitoring; systems serving 3,300 or fewer persons can take grab samples in lieu of continuous monitoring at the following frequency

Population	Samples/Day
<500	1
501 — 1,000	2
1,001 — 2,500	3
2,501 — 3,300	4

A disinfectant residual must be detected in 95% or more of the monthly distribution system samples.

iii. fluoride by continuous monitoring or by daily monitoring (using grab sampling) when the treatment process includes fluoridation. All other supply systems should monitor fluoride annually by taking a grab sample if natural fluoride is detected in the initial sample, otherwise every five years.

iv. volatile organics (Table A) quarterly if detected in the first sample or if the supply is vulnerable. Once every five years if not detected in the first sample. The exception is Trihalomethanes (chloroform, bromoform, chlorodibromomethane, bromodichloromethane), which are to be monitored quarterly.

v. inorganics (Table B) annually. After three consecutive samples show concentrations less than the MAC, frequency may be reduced to once per three years.

vi. nitrates/nitrites once quarterly.

vii. pesticides (Table C) and PCB quarterly at supplies considered to be vulnerable (e.g. agricultural basin). All other supply systems must be monitored once every ten years.

4.2.1.2 Surface or Ground Water With Filtration

All Public Water Supply Systems using surface water or ground water under the direct influence of surface water and performing filtration by conventional or direct filtration, slow sand filtration or diatomaceous earth filtration must monitor -

i. turbidity levels, using a grab sample, every four hours or by continuous monitoring. Systems serving fewer than 500 persons can reduce monitoring to one grab sample per day.

ii. disinfection residuals as per 4.2.1.1(ii)

iii. fluoride as per 4.2.1.1(iii)

iv. volatile organics as per 4.2.1.1(iv)

v. inorganics as per 4.2.1.1(v)

vi. nitrates/nitrites as per 4.2.1.1(vi)

vii. pesticides and PCB as per 4.2.1.1(vii)

4.2.1.3 Ground Water Source

All Public Water Supply Systems using ground water must sample at points of entry to the system (after the application of treatment). This means that the water from a well has to be sampled before it is combined with other water in the distribution system. For example, if a system has four wells, each with a unique entry point to the distribution system, four separate samples would have to be taken each sampling period. If a system has four wells that are combined before entry to the distribution system, only one sample is required. Water must be monitored for:

i. turbidity levels using a grab sample once per day. If possible the grab sample should be collected immediately before the first point that the disinfection is applied. If routine microbiological sampling indicates no adverse water quality and the site is considered to have adequate disinfection, turbidity monitoring is voluntary.

ii. disinfectant residuals in the distribution system at the same frequency as the one required by the microbiological sampling (Table 5).

iii. volatile organics as per 4.2.1.1.(iv).

iv. inorganics (Table B) once every three years.

v. nitrates/nitrites annually. If four consecutive samples contain nitrate/nitrite greater than 50% of the MAC, frequency must be increased to four times per year.

vi. pesticides and PCB as per 4.2.1.1(vii).

All supplies regardless of source should monitor and record all taste and odour complaints from the consumer and appropriate remedial action should be taken.

4.2.2 Assessment and Corrective Action

If the results of analyses indicate that the level of any parameter exceeds its MAC, immediate resampling is required. If the results of the resampled water exceed the MAC, then the MOH and the MOEE should be notified and monitoring at a frequency designated by the District Officer must continue in order to define the source. Monitoring should be continued until the problem has been eliminated.

Regardless of source, when a pesticide or volatile is detected above trace levels, unless known to be a by-product of the treatment process, a corresponding raw water sample must be taken and analyzed.

For ground water supplies, where it is noted that a 15 minute chlorine contact time is not being maintained, chlorine residual must be monitored at the closest consumer at the same frequency as required for microbiological sampling (Table 5). Corrective action must be taken when adequate disinfection is not detected as per 4.1.3.

4.3 Radiological Parameters

4.3.1 Sampling and Analysis

The frequency of sampling for radionuclides is dependent on the concentration present in the supply. The higher the concentration of a radionuclide the more frequent the sampling. Where water sources are subject to discharges of radioactive waste, the sampling frequency for specific radionuclides may be increased as recommended by the MOEE.

Most radionuclides can either be measured directly or expressed in terms of surrogate measurements such as gross alpha emission (e.g. radium-226) and gross beta emission (e.g. strontium-90, iodine-131, cesium-137). The gross alpha and gross beta determinations are only suitable for preliminary screening procedures. Compliance with the objectives may be inferred if these are less than the most stringent MACs (see Table 4). When these limits are exceeded, the specific radionuclides must be measured directly. Tritium, a gross beta emitter, must be measured separately because the screening process is not sufficiently sensitive to detect low levels of tritium.

4.3.2 Assessment and Corrective Action

If the MAC is exceeded the water should be immediately resampled. If any result in the resampled water exceeds its MAC, then the MOH and the MOEE should be notified and monitoring at a frequency designated by the District Officer shall continue in order to define the source. Monitoring should be continued until the problem has been eliminated.

Table A - Volatile Organics

Benzene
Carbon Tetrachloride
1,2-Dichlorobenzene
1,4-Dichlorobenzene
Dichloromethane
Ethylbenzene
Monochlorobenzene
Toluene
Trichloroethylene
Trihalomethanes
Xylene

Table B - Inorganics

Arsenic
Barium
Boron
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Selenium
Uranium

Table C - Pesticides and PCB

Alachlor
Aldicarb
Aldrin+Dieldrin
Atrazine
Azinphos-methyl
Bendiocarb
Bromoxynil
Carbaryl
Carbofuran
Chlordane
Chlorpyrifos
Cyanazine
Diazinon
Dicamba
DDT
2,4-D
Diclofop-methyl
Dimethoate
Diquat
Diuron
Glyphosate
Heptachlor + heptachlor epoxide
Lindane
Malathion
Methoxychlor
Metolachlor
Metribuzin
Paraquat
Parathion
Phorate
Picloram
PCB
Simazine
Temephos
Terbufos
Triallate
Trifluralin

APPENDIX A

DESCRIPTION OF INDIVIDUAL PARAMETERS

Alachlor (pesticide) (new[1])

The interim maximum acceptable concentration (IMAC) for alachlor in drinking water is 0.005 mg/L. This IMAC was developed in February 1985 by Health Canada, at the request of the Ontario government, in response to detection of this herbicide in municipal and private drinking water. Alachlor is a chloroacetanilide herbicide that was used mainly on corn and soybeans to control the growth of weeds. It was applied to cornfields prior to corn emergence to kill annual grasses. Alachlor is a proven animal carcinogen and a possible human carcinogen. In November of 1985, the use of alachlor was banned in Canada.

Aldicarb (pesticide) (new)

The maximum acceptable concentration for aldicarb in drinking water is 0.009 mg/ L. Aldicarb is a carbamate insecticide used in relatively low quantities for the control of specified insects. It is used on potatoes as well as on sugar beets and greenhouse ornamentals for aphid and root maggot control . Since aldicarb is highly soluble in water, persistent and mobile in soils, it has a high potential to enter ground water supplies. Available evidence suggests that aldicarb is not carcinogenic. The use of aldicarb was withdrawn by the manufacturer in the late 1980s.

Aldrin + Dieldrin (pesticide)

The maximum acceptable concentration for aldrin+dieldrin in drinking water is 0.0007 mg/L. Aldrin is an organochlorine pesticide and was used to control soil insects. It is not often found in aquatic systems because it quickly oxidizes to dieldrin, which is very persistent. Most uses of aldrin and dieldrin were banned in Ontario in 1969 except for termite control under appropriate circumstances. This remaining use was banned in Ontario in April, 1994.

[1] New indicates that the substance is new to this edition of the Ontario drinking Water Objectives

Alkalinity (inorganic)

The operational range for alkalinity in drinking water is 30 to 500 mg/L expressed as calcium carbonate. This range ensures sufficient alkalinity for optimum floc formation during the coagulation process. Alkalinity is a measure of the buffering capacity of water. Waters with low alkalinity will tend to corrode iron and produce "red water" while highly alkaline waters may produce incrustations on utensils, service pipes and water heaters. Waters with an extremely high alkalinity can produce gastrointestinal discomfort. The operating range of 30 to 500 mg/L as calcium carbonate does not guarantee elimination of all alkalinity related problems. It is suggested that each water be evaluated on its own merit with respect to alkalinity, taking into consideration relative amounts of carbonate, bicarbonate and hydroxyl ions, total dissolved solids, calcium and pH.

Aluminum (inorganic)

The operational guideline in drinking water for aluminum is 0.1 mg/L. Aluminum is the third most abundant element in nature, which accounts for its presence in practically all natural waters. When alum (hydrated aluminum sulphate) is used as a coagulant in water treatment, the measurement of the residual aluminum in the treated water is important to monitor treatment efficiency. High residual aluminum can cause coating of the pipes in the distribution system resulting in increased energy requirements for pumping, interferences for certain industrial processes and post-flocculation.

Potential health effects of aluminum in drinking water are currently under review. The current operational guideline recommends that residual aluminum be maintained at a level below 0.1 mg/L in the water leaving the plant.

Arsenic (inorganic) (revised)

The interim maximum acceptable concentration for arsenic in drinking water is 0.025 mg/L. Arsenic is classified as a known carcinogen, both through inhalation and ingestion.

Arsenic is introduced into water through the natural dissolution of minerals, industrial effluents and atmospheric pollution. Except in areas close to natural, agricultural, or industrial sources of arsenic contamination, arsenic is present at very low concentrations in surface waters.

Atrazine (pesticide) (new)

The interim maximum acceptable concentration for atrazine plus N-dealkylated metabolites in drinking water is 0.005 mg/L. Atrazine, a triazine pesticide, is used mainly as a pre-emergent or post-emergent herbicide on corn for annual grass control. There is no evidence to suggest that atrazine is carcinogenic.

Azinphos-methyl (pesticide) (new)

The maximum acceptable concentration for azinphos-methyl in drinking water is 0.02 mg/L. Azinphos-methyl, an organophosphorus insecticide, is a broad spectrum insecticide used against foliage-feeding insects. Available evidence suggests that azinphos-methyl is not carcinogenic.

Barium (inorganic) (revised)

After assessment of current data, the Federal-Provincial Subcommittee on Drinking Water has revised the previous maximum acceptable concentration to a new maximum acceptable concentration of 1.0 mg/L for barium in drinking water. Barium is a common constituent of the earth's crust but in aquatic systems is seldom present at concentrations greater than 1 mg/L. Ingestion of barium can result in serious physiological effects. At very low levels, the toxicological effects of barium are not as well understood. However, the maximum acceptable concentration of 1.0 mg/L is considered adequate to provide a satisfactory safety margin. Most treatment methods used for water softening are effective for barium removal.

Bendiocarb (pesticide) (new)

The maximum acceptable concentration for bendiocarb in drinking water is 0.04 mg/L. Bendiocarb is a carbamate insecticide used to control specific insects in buildings and greenhouses. Available evidence suggests that this insecticide is not carcinogenic.

Benzene (organic) (new)

The maximum acceptable concentration of benzene in drinking water is 0.005 mg/L. Benzene is used in the manufacture of organic chemicals and enters water from industrial effluents and atmospheric pollution. Benzene is known to be a human carcinogen. Benzene is reported to occur in vehicle emissions and cigarette smoke.

Human exposure to benzene is primarily through inhalation of vapour or through skin absorption. Food is probably the main source of ingested benzene. Drinking water is not a major source.

Benzo(a)pyrene (organic)(new)

The maximum acceptable concentration for benzo(a)pyrene in drinking water is 0.00001 mg/L. Benzo(a)pyrene, a polynuclear aromatic hydrocarbon, is formed during the combustion (at low temperatures) of organic matter and is a component of coal tar. It is practically insoluble in water.

Boron (inorganic)(revised)

The maximum acceptable concentration for boron in drinking water has been revised to an interim maximum acceptable concentration of 5.0 mg/L. Boron in water is most commonly found in the form of boric acid. In humans a number of acute boron poisonings have resulted from the use of borates as antiseptic agents and from accidental ingestion, however these levels of exposure were much higher than would be encountered through drinking water. Infants, the elderly and individuals with kidney diseases are most susceptible to the toxic effects of boron compounds.

Bromoxynil (pesticide)(new)

The interim maximum acceptable limit for bromoxynil in drinking water is 0.005 mg/L. Bromoxynil is a hydroxybenzonitrile herbicide used in Ontario for the control of specific weed seedlings in grain crops. Available evidence suggests that bromoxynil is not carcinogenic.

Cadmium(inorganic)

The maximum acceptable concentration for cadmium in drinking water is 0.005 mg/L. Cadmium is a relatively rare element that is uniformly distributed in the earth's crust. Water can be contaminated with cadmium from natural or industrial sources. Cadmium compounds used in plumbing materials may also be a significant source of drinking water contamination. Corrosion control can reduce cadmium contamination resulting from plumbing material in drinking water. Other than occupational exposure and inhalation from cigarette smoke, food is the main source of cadmium intake. Cadmium is a highly toxic element. A provisional tolerable weekly cadmium intake of 0.4 to 0.5 mg for an adult has been estimated by a joint FAO/WHO[1] expert

committee. It is difficult to control the cadmium dose from food therefore, the amount allowed in drinking water is as low as possible. Daily consumption of 1.5 litres of water containing 0.005 mg/L, would contribute 12 percent of the tolerable intake.

Carbaryl (pesticide)

The maximum acceptable concentration for carbaryl in drinking water is 0.09 mg/L. Carbaryl is a broad spectrum carbamate insecticide used in agriculture and forestry for control of foliar pests and as a home and garden product for specific garden and lawn pests. It is also used for ectoparasite control on livestock and pets. Available evidence suggests that carbaryl is not carcinogenic.

Carbofuran (pesticide) (new)

The maximum acceptable concentration for carbofuran in drinking water is 0.09 mg/L. Carbofuran is a broad spectrum carbamate insecticide used in agriculture for control of foliar pests. It may also be used to treat soil at planting time to control root maggot, wireworm and some species of nematodes. Available evidence suggests that carbofuran is not carcinogenic.

Carbon tetrachloride (organic) (new)

The maximum acceptable concentration for carbon tetrachloride in drinking water is 0.005 mg/L. Carbon tetrachloride is classified as probably carcinogenic to humans.

Cesium-137 (radiological)

The maximum acceptable concentration for cesium-137 in drinking water is 50 Bq/L. Cesium-137 is a radionuclide that can enter water as a result of nuclear industry discharge and fallout from nuclear tests. Ingestion of radionuclides in drinking water may result in cancer to exposed individuals and genetic changes in their progeny. The probability of inducing such results is assumed to be proportional to the radiation dose delivered to sensitive organs and tissues. It is assumed that no threshold level exists below which the probability of induced effects is zero. For practical purposes, it is necessary to select maximum acceptable concentrations in water for radionuclides in order to protect consumers of drinking water from unacceptable

[1] Food and Agriculture Organization/World Health Organization

risks. Cesium-137 is a significant radionuclide in aqueous discharges from nuclear reactors. Water consumption contributes approximately 2% of the total daily intake.

Chlordane (pesticide)

The maximum acceptable concentration for chlordane in drinking water is 0.007 mg/L. Chlordane is a cyclodiene insecticide that was once used extensively in agriculture as a soil insecticide and for domestic control of cockroaches, ants and termites. It is a very persistent insecticide in soil. Chlordane will be banned in Ontario in April, 1994.

Chloride (inorganic)

The aesthetic objective for chloride in drinking water is 250 mg/L. Chloride is widely distributed in nature, generally as the sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$) salts. Chloride levels in the body are well regulated and, in reasonable concentrations chloride is not harmful to humans. At concentrations above 250 mg/L chloride may impart an undesirable taste to water.

Chlorpyrifos (pesticide) (new)

The maximum acceptable concentration for chlorpyrifos in drinking water is 0.09 mg/L. Chlorpyrifos is an organophosphorus insecticide used for the control of mosquitoes, flies, various crop pests in soils and on foliage, household pests, termites and aquatic larvae. It is also used on sheep and cattle for the control of ectoparasites. Available evidence suggests that chlorpyrifos is not carcinogenic.

Chromium (inorganic)

The maximum acceptable concentration for chromium in drinking water is 0.05 mg/L. Trivalent chromium, the most common and naturally occurring state of chromium, is not considered to be toxic. However, if present in raw water, it may oxidize to the more harmful hexavalent chromium during chlorination.

Colour (physical)

The aesthetic objective for colour in drinking water is 5 True Colour Units (TCU). Colour in drinking water may be due to the presence of natural or synthetic organic parameters as well as certain metallic ions such as iron, manganese and copper. Colour may become noticeable to consumers at levels greater than 5 TCU.

Copper (inorganic)

The aesthetic objective for copper in drinking water is 1.0 mg/L. Copper occurs naturally in the environment, is used extensively in household plumbing and is an essential element for the human metabolism. Drinking water has the potential to leach copper from piping. At levels above 1.0 mg/L, copper may impart an objectionable taste to the water. Although the intake of large doses of copper has resulted in adverse health effects, the levels at which this occurs are much higher than the aesthetic objective and at elevated levels not normally found in drinking water.

Cyanazine (pesticide) (new)

The interim maximum acceptable concentration for cyanazine in drinking water is 0.01 mg/L. Cyanazine is a triazine herbicide registered for control of weeds in crop and non-crop areas. Available evidence suggests that cyanazine is not carcinogenic.

Cyanide (inorganic)

The maximum acceptable concentration for cyanide in drinking water is 0.2 mg/L. Cyanide is widely used in industry, and industrial effluents are the major sources of cyanide contamination. Cyanide at levels less than 10 mg/L is readily detoxified in the body to thiocyanate. Lethal toxic effects of cyanide usually occur only when this detoxification mechanism is overwhelmed. The maximum acceptable concentration for free cyanide provides a safety factor of approximately 25. Adequate chlorination will oxidize cyanide and reduce it to a level below this limit. Cyanogen chloride, with an oral toxicity 25 times less acute than the cyanide ion, is formed as a result of the chlorination process.

2,4-D (2,4-Dichlorophenoxy acetic acid) (pesticide)

The interim maximum acceptable concentration for 2,4-D in drinking water is 0.1 mg/L. 2,4-D is a chlorophenoxy herbicide used for control of broadleaf weeds in cereal crops and lawns.

DDT (Dichlorodiphenyltrichloroethane) and Metabolites (pesticides)

The maximum acceptable concentration of DDT and its metabolites in drinking water is 0.03 mg/L. Its persistence in the environment and concerns with potential biomagnification resulting in potential widespread damage to the environment resulted in use restrictions in North America by the late 1960's. DDT was banned in Ontario in 1988.

Diazinon (pesticide)

The maximum acceptable concentration for diazinon in drinking water is 0.02 mg/L. Diazinon is an organophosphorus insecticide that is used to control foliar and soil dwelling pests. It is also used for control of flies in barns and for ant and cockroach control. Available evidence suggests that diazinon is not carcinogenic.

Dicamba (pesticide) (new)

The maximum acceptable concentration for dicamba in drinking water is 0.12 mg/L. Dicamba is a benzoic acid herbicide that is used for control of broadleaf weeds in grains, corn, flax, sorghum, pastures and weed control in lawns. Available evidence suggests that dicamba is not carcinogenic.

Diclofop-methyl (pesticide) (new)

The maximum acceptable concentration for diclofop-methyl in drinking water is 0.009 mg/L. Diclofop-methyl is a chlorophenoxy derivative used for control of annual grasses in grain and vegetable crops. It is relatively soluble in water. Available evidence suggests that diclofop-methyl is not carcinogenic.

1,2-Dichlorobenzene (organic) (new)

The maximum acceptable concentration for 1,2-dichlorobenzene in drinking water is 0.2 mg/L and the aesthetic objective is 0.003 mg/L. Although health effects from 1,2-dichlorobenzene are negligible below 0.2 mg/L, it does impart an unpleasant taste to water if present above 0.003 mg/L. It is used in a variety of specialty chemical blends (degreasing agents, imported dye carriers). There is sufficient evidence to suggest that 1,2-dichlorobenzene is probably non-carcinogenic.

1,4-Dichlorobenzene (organic) (new)

The maximum acceptable concentration for 1,4-dichlorobenzene in drinking water is 0.005 mg/L and the aesthetic objective is 0.001 mg/L. At levels above 0.001 mg/L 1,4-dichlorobenzene imparts an unpleasant taste to the water. It is used in deodorant blocks and moth balls. The main exposure route is inhalation. Exposure through drinking water is negligible.

1,2-Dichloroethane (organic) (new)

An interim maximum acceptable concentration for 1,2-dichloroethane in drinking water is 0.005 mg/L. 1,2-Dichloroethane is one of the most widely used synthetic compounds in the world. It is principally used as a starting material in the production of vinyl chloride, as a lead scavenger in gasoline formulations, a solvent and a fumigant. It is released into the environment via atmospheric emissions and the discharge of industrial waste waters. There is sufficient evidence to suggest that 1,2-dichloroethane is an animal carcinogen, but inadequate data to determine human carcinogenicity.

Dichloromethane (organic) (new)

The maximum acceptable concentration for dichloromethane in drinking water is 0.05 mg/L. Methylene chloride is an alternative name for dichloromethane. It is used extensively as an industrial solvent for paint-stripping, a degreasing agent and as an aerosol propellant. There is sufficient data to show that dichloromethane is an animal carcinogen but inadequate data to determine human carcinogenicity.

2,4-Dichlorophenol (organic) (new)

The maximum acceptable concentration for 2,4-dichlorophenol in drinking water is 0.9 mg/L and the aesthetic objective is 0.0003 mg/L. At levels above 0.0003 mg/L, 2,4 dichlorophenol will impart an unpleasant taste to the water. Chlorophenols may be introduced into water during their manufacture and/or use or through degradation of other chemicals. Chlorophenols are no longer manufactured in Canada, however, they continue to be imported. They are widely used in the manufacture of pesticides. Chlorophenols may form as a result of the chlorination of humic matter or of natural carboxylic acids during disinfection. There are inadequate data to classify 2,4-dichlorophenol with respect to its potential carcinogenicity, so additional safety factors have been incorporated into the maximum acceptable concentration.

Dieldrin + Aldrin (pesticide)

see Aldrin + Dieldrin

Dimethoate (pesticide) (new)

The interim maximum acceptable concentration for dimethoate in drinking water is 0.02 mg/L. Dimethoate is an organophosphorus miticide and insecticide used on a wide range of plants for control of mites and both sucking and leaf-feeding insects. It is also used for fly control in livestock pens. Concentrated preparations can be painted on the trunk and main limbs of large trees to control leaf miner. Available evidence suggests that dimethoate is not carcinogenic.

Dinoseb (pesticide) (new)

The maximum acceptable concentration for dinoseb in drinking water is 0.01 mg/L. Dinoseb is a contact herbicide and desiccant. Dinoseb is no longer used in Ontario.

Dioxin (organic) (new)

The interim maximum acceptable concentration for dioxin (and furan) in drinking water is 15 pg/L as 2,3,7,8,-TCDD toxicity equivalents (TEQ)/L. Dioxin refers to two related families of chemical compounds known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Only seventeen of these compounds are considered to have sufficient toxicity to be of concern and these are expressed as a single number to indicate the overall toxicity of the complex mixture encountered in the environment. PCDDs and PCDFs are unavoidable by-products created in the manufacture of other chemicals, such as some pesticides (eg. 2,4,5-T), or are created as a result of the incomplete combustion of mixtures containing chlorine atoms and organic compounds. They are also formed by the kraft bleaching process in pulp and paper mills which is one of the main sources of PCDDs and PCDFs in water. Other sources of PCDDs in the environment are from forest fires, cigarette smoke, incineration or the use of products which contain trace amounts of PCDDs or PCDFs.

Diquat (pesticide) (new)

The maximum acceptable concentration for diquat in drinking water is 0.07 mg/L. Diquat is a bipyridilium herbicide used primarily as a crop desiccant in seed crops and as an aquatic herbicide. Available evidence suggests that diquat is not carcinogenic.

Dissolved Organic Carbon (DOC) (Physical)

The aesthetic objective for dissolved organic carbon (DOC) in drinking water is 5 mg/L. High levels of organic carbon in water may be a result of excess naturally occurring or human-derived matter. Colour, taste and odour, and turbidity problems may be associated with high levels of dissolved organic carbon. Elevated levels may provide precursors for the formation of potentially harmful contaminants during chlorination.

The DOC test is not a direct indicator of adverse health effects, since some waters with a low organic content may contain minute concentrations of toxic organic chemicals. The DOC is more of an indicator of possible water quality deterioration during storage and distribution. Dissolved organic carbon replaces total organic carbon as a more accurate laboratory test for the presence of organic material. The DOC test measures almost all of the dissolved organic constituents in the water, however, volatile hydrocarbon gases and low molecular weight haloform compounds are incompletely recovered.

Diuron (pesticide) (new)

The maximum acceptable concentration for diuron in drinking water is 0.15 mg/L. Diuron is a substituted urea-based herbicide used for the control of vegetation in crop and non-crop areas, including industrial sites and rights-of-way. It is moderately soluble in water. Diuron is not acutely toxic. Available evidence suggests that diuron is not carcinogenic.

Escherichia coli (Escherichia coli) (microbiological) (new)

Escherichia coli should not be detected in any drinking water sample. *Escherichia coli* is a fecal coliform and can be detected using membrane filtration or presence/absence methods. Since *Escherichia coli* is present in fecal matter and prevalent in sewage, it is a good indicator of recent fecal pollution. For more detail see Section 4.1.2 "Indicators of Unsafe Drinking Water Quality".

Ethylbenzene (organic) (new)

The aesthetic objective for ethylbenzene in drinking water is 0.0024 mg/L. Ethylbenzene is an organic which will impart an unpleasant taste to the water in concentrations above 0.0024 mg/L. Ethylbenzene is used in the manufacture of styrene and acetophenone and as an industrial solvent. It has been detected in the exhaust of gasoline and diesel engines.

Fecal coliform (microbiological)

Fecal coliforms should not be detected in any drinking water sample. The fecal coliform group are a portion of the coliform group that is capable of fermenting lactose at 44 to 45 °C within 48 hours. *Escherichia coli* is the fecal coliform most frequently associated with recent fecal pollution. The presence of fecal coliforms in drinking water is an indication of sewage contamination. For more detail see Section 4.1.2 "Indicators of Unsafe Drinking Water Quality".

Fluoride (inorganic) (revised)

Where fluoridation of drinking water is practised, it is recommended that the concentration be adjusted to 1.0 (+/- 0.2) mg/L, the optimum level for control of dental caries. Communities in Northern Ontario, where the annual mean daily maximum temperature is less than 10 °C may wish to consider adjusting the fluoride concentration to 1.2 (+/- 0.2) mg/L.

Adverse effects of fluoride in drinking water above 1.5 mg/L and below 2.4 mg/L are cosmetic in nature (dental mottling in a small proportion of the population). Levels above 1.5 mg/L should be reported to the local medical officer of health. The local medical officers of health in Ontario have been advised by the Ministry of Health that an educational approach to control total fluoride intake in areas naturally higher in fluoride than the 1.5 mg/L MAC for added fluoride can effectively control the problem of fluorosis. The medical officer of health may undertake stronger measures than an educational program if natural fluoride levels exceed 2.4 mg/L.

Glyphosate (pesticide) (new)

The interim maximum acceptable concentration for glyphosate in drinking water is 0.28 mg/L. Glyphosate is a non-selective herbicide used for weed control on rights-of-way, forestry plantations and in site preparations for planting of crops. It is very soluble in water. Available evidence suggests that glyphosate is not carcinogenic.

Hardness (inorganic)

The operational guideline for hardness in drinking water is between 80 and 100 mg/L as calcium carbonate. Hardness in drinking water can have significant aesthetic and economic effects. Hardness is caused by dissolved polyvalent metallic ions, principally calcium and magnesium, and is expressed as the equivalent quantity of calcium carbonate. On heating, hard water has a tendency to form scale deposits and can also result in excessive soap consumption. Conversely, soft water may result in the corrosion of water pipes. Depending on the interaction of other factors such as pH and alkalinity, hardness levels between 80 and 100 mg/L as calcium carbonate ($CaCO_3$) are considered to provide an acceptable balance between corrosion and incrustation. Water supplies with a hardness greater than 200 mg/L are considered poor but tolerable. Hardness in excess of 500 mg/L in drinking water is unacceptable for most domestic purposes (see sodium).

Heptachlor + Heptachlor epoxide (pesticide)

The maximum acceptable concentration of heptachlor + heptachlor epoxide in drinking water is 0.003 mg/L. Heptachlor is a cyclodiene insecticide once used in agriculture for control of soil insects. Heptachlor use has been banned in Canada since 1969.

Heterotrophic Plate Count (HPC) (microbiological)

The heterotrophic plate count (HPC) (35 °C, 48 hours) in drinking water should not exceed 500 colonies per mL. The HPC is a microbiological test used to determine the quality of the water in terms of its general bacterial content. This test is used as a supplement to the routine analysis for coliform bacteria. Heterotrophic plate counts can also be used to monitor disinfection efficiency at water treatment plants and as a measure of water quality deterioration in distribution lines (eg. biofilm formation) and reservoirs. Standard plate count has been renamed heterotrophic plate count.

Iodine-131 (Radiological)

The maximum acceptable concentration for iodine-131 in drinking water is 10 Bq/L. Iodine-131 is an important radionuclide in the fallout from nuclear weapons testing and in emissions from nuclear reactors. Environmental levels depend strongly on meteorological conditions and show sharp local fluctuations. Due to the short half-life of iodine-131, the potential health hazard persists for only a short time after it is released.

Iron (inorganic)

The aesthetic objective for iron in drinking water is 0.3 mg/L. Excessive levels of iron in drinking water supplies are objectionable for a number of reasons: at levels higher than the aesthetic objective of 0.3 mg/L, iron may impart a brownish colour to laundered goods; it may produce a bitter, astringent taste in water and beverages; and the precipitation of iron can also promote the growth of iron bacteria in treated water mains and service pipes. When ferric chloride is used as a coagulant, the residual iron can assist in measuring treatment efficiency.

Lead (inorganic) (revised)

The maximum acceptable concentration for lead in drinking water is 0.01 mg/L. This objective applies to water at the point of consumption. Ingestion of lead can result in serious illness or death. Lead is a cumulative general poison, with foetuses, infants, children up to six years of age and pregnant woman (because of their foetuses) being most susceptible to adverse health effects.

Lead can enter drinking water, particularly in soft or aggressive water areas, through contact with lead solder or lead service connections. In order to minimize exposure to lead introduced into drinking water from plumbing systems, it is recommended that only the cold water supply be used, after an appropriate period of flushing to rid the system of standing water, for analytical sampling, drinking, beverage preparation and cooking.

Lindane (pesticide)

The maximum acceptable concentration for lindane in drinking water is 0.004 mg/L. Lindane is an organochlorine insecticide used for seed treatment and may also be used in pharmaceutical preparations of scabicide and pediculocide shampoos. The chemical name for lindane is gamma-BHC (hexachlorocyclohexane). Technical grades of lindane will contain small percentages of the á and ß isomers. Available evidence suggests that lindane is not carcinogenic.

Malathion (pesticide) (new)

The maximum acceptable concentration for malathion in drinking water is 0.19 mg/L. Malathion is an organophosphorus insecticide. It has low mammalian toxicity.

Manganese (inorganic)

The aesthetic objective for manganese in drinking water is 0.05 mg/L. Like iron, manganese is objectionable in water supplies because it stains laundry, and at excessive concentrations causes undesirable tastes in beverages. Difficulties may commence in some waters with a manganese concentration as low as 0.05 mg/L. Manganese may also encourage the build up of a slimy coating in piping, which can slough off as black precipitate.

Mercury (inorganic)

The maximum acceptable concentration for mercury in drinking water is 0.001 mg/L. Possible sources of mercury in drinking water include industrial effluents, and irrigation or drainage of areas in which agricultural pesticides are used. Mercury is a toxic element and serves no known physiological benefit to man. Alkyl compounds of mercury are the most toxic to man resulting in illness, irreversible neurological damage, or death. Food is the major source of human exposure to mercury, and fish, which bio-concentrate organic mercury in their tissues, are the most important food source of mercury. Long-term daily ingestion of approximately 0.25 mg of mercury as methyl mercury has caused the onset of neurological symptoms. The maximum acceptable concentration for mercury in drinking water of 0.001 mg/L, provides a considerable margin of safety.

Methane (organic)

The aesthetic objective for methane in drinking water is 3 L/m^3. Methane contamination may be a problem in well supplies. Methane occurs naturally in ground water and acts as a stimulant for organic fouling conditions in the distribution system. Methane is not represented in dissolved organic carbon (DOC) analysis and its carbonaceous content is, therefore, additional to any DOC result. Experience has shown that methane, at levels up to the 3 L/m^3, can be controlled by chlorination, given a clean distribution system. Methane under pressure will come out of solution if the pressure is reduced, resulting in a cloudy appearance in freshly drawn water. This should not be a problem at methane levels less than 3 L/m^3. If methane is allowed to accumulate in confined areas, such as well pits or parts of distribution systems and plumbing, the potential for explosion exists.

Methoxychlor (pesticide)

The maximum acceptable concentration for methoxychlor in drinking water is 0.9 mg/L. Methoxychlor is an organochlorine insecticide. It is non-persistent and non-accumulative in biological tissues, making it an attractive insecticide for use on products nearing harvest, in dairy barns for housefly control and as either a larvicide or adulticide against black flies and mosquitoes. Available evidence suggests that methoxychlor is not carcinogenic.

Metolachlor (pesticide) (new)

The interim maximum acceptable concentration for metolachlor in drinking water is 0.05 mg/L. Metolachlor is a selective herbicide used for pre-emergence and pre-plant weed control in corn, soybeans, peanuts, grain sorghum, pod crops, woody ornamentals and sunflowers. Available evidence suggests that metolachlor is not carcinogenic.

Metribuzin (pesticide) (new)

The maximum acceptable concentration for metribuzin in drinking water is 0.08 mg/L. Metribuzin is a triazine herbicide used for control of broad leaf weeds and grasses infesting agricultural crops. It is used selectively on soybeans, tomatoes and potatoes, all crops that are highly sensitive to most other triazine herbicides. Available evidence suggests that metribuzin is not carcinogenic.

Monochlorobenzene (organic) (new)

The maximum acceptable concentration for monochlorobenzene in drinking water is 0.08 mg/L and the aesthetic objective is 0.03 mg/L. At concentrations above 0.03 mg/L monochlorobenzene will impart an unpleasant taste to the water. Monochlorobenzene is used in the production of chloronitrobenzene and diphenyl ether, as a rubber intermediate, and as a solvent in adhesives, paints, waxes, polishes and inert solvents. It is also used in metal cleaning operations and may be present in industrial discharges.

Nitrate (inorganic)

The maximum acceptable concentration of nitrates in drinking water is 10 mg/L as nitrogen (N). Nitrates are present in water (particularly ground water) due to contamination by decaying plant or animal material, agricultural fertilizers, domestic sewage, or geological formations containing soluble nitrogen compounds. There is a causal relationship between the presence of nitrate in drinking water and infantile methaemoglobinaemia. The nitrate ion is not directly responsible for this disease, but must first be reduced to the nitrite ion by intestinal bacteria. The nitrite ion reacts with the iron of haemoglobin to produce methaemoglobin, an altered haemoglobin, which is unable to transfer oxygen. The affected tissues become oxygen-starved.

Nitrate poisoning, in terms of methaemoglobinaemia, from drinking water appears to be restricted to susceptible infants. Older children and adults drinking the same water are unaffected. Most water-related cases of methaemoglobinaemia have been associated with the use of water containing more than 10 mg/L nitrate as N or 45 mg/L nitrate, as NO_3. In Canada, no cases have been reported where the nitrate concentration was consistently less than the maximum acceptable concentration. Where both nitrate and nitrite are present, the total nitrate plus nitrite-nitrogen concentration should not exceed 10 mg/L. In areas where the nitrate content of water is known to exceed the maximum acceptable concentration the public should be informed by the appropriate health authority of the potential dangers of using the water for infants.

Although the guideline is based principally on effects in the most sensitive subgroup (ie infants), it would be prudent to minimize exposure of the entire population, owing to the weak evidence of an association between gastric cancer and high levels of nitrate in drinking water. This statement was prompted following a review of recent information on nitrate by the Federal-Provincial Subcommittee on Drinking Water.

Nitrite (inorganic)

The maximum acceptable concentration of nitrite in drinking water, 1.0 mg/L as N, is based, as with nitrate, primarily on the relationship between nitrite in water and the incidence of infantile methaemoglobinaemia. Nitrite is quickly oxidized to nitrate and is therefore seldom present in surface waters in significant concentrations. Nitrite may occur in ground water sources, however, if chlorination is practised the nitrite will oxidize to nitrate. The contribution of nitrite from drinking water to the total daily intake would be negligible for most public water supplies.

Nitrilotriacetic Acid(NTA) (organic)(revised)

The maximum acceptable concentration for nitrilotriacetic acid (NTA) in drinking water is 0.40 mg/L. Nitrilotriacetic acid (NTA) has many industrial applications but its main use is in laundry detergents. Most of the NTA used is eventually disposed of in domestic sewage, and thus, is a potential contaminant of drinking water supplies. In general, the toxicity of NTA is very low, however, an increased incidence of urinary tract tumours was found in rats and mice that had been fed very large doses of NTA. Risk assessment together with the relatively poor absorption of NTA by man suggests that the risk associated with a NTA level in drinking water of 0.40 mg/L is negligible.

N-Nitrosodimethylamine (organic)

The interim maximum acceptable concentration for N-nitrosodimethylamine (NDMA) is 0.000009 mg/L. NDMA is presently used as an antioxidant, as an additive for lubricants, and as a softener of copolymers. NDMA is an animal carcinogen although there is insufficient evidence to classify it as a human carcinogen.

Odour (physical)

Although an odour can often be attributed to a specific parameter, it is usually impractical and often impossible to isolate and identify the odour-producing chemical. Evaluation of this parameter is therefore dependent on individual sense of smell, but because odour cannot be objectively measured, a numerical limit has not been specified. The odour of drinking water should be inoffensive.

Organic Nitrogen (organic)

The operational guideline for organic nitrogen in drinking water is 0.15 mg/L. Excess organic nitrogen (as represented by the total Kjeldahl nitrogen concentration minus the ammonia nitrogen concentration) may be associated with organic fouling in the distribution system and some types of chlorine-enhanced taste problems. Nitrogen-containing organics are measured in dissolved organic carbon (DOC) determinations, but, because of the nutritive value of nitrogen, their contribution to biological fouling is greater than would be suggested from DOC analysis. Organic nitrogen at levels above 0.15 mg/L would be typically associated with DOC of 0.6 mg/L. Organic nitrogen compounds frequently contain amine groups which can react with chlorine. Certain chlorinated organic nitrogen compounds may be responsible for flavour problems that are associated with chlorophenol. Taste and odour problems have been usually associated with organic nitrogen levels greater than 0.15 mg/L.

Paraquat (pesticide) (new)

The interim maximum acceptable concentration for paraquat in drinking water is 0.01 mg/L. Paraquat is a bipyridyl herbicide used as a contact herbicide and for desiccation of seed crops. It is also used for non-crop and industrial weed control. It is a pre-emergent herbicide used in "no-till" situations or before planting or crop emergence. It is also registered for aquatic use to control cattails, bulrushes and grasses. Available evidence suggests that paraquat is not carcinogenic.

Parathion (pesticide) (revised)

After assessment of recent toxicity data the guideline was revised by the Federal-Provincial Subcommittee. The maximum acceptable concentration for parathion in drinking water is 0.05 mg/L. Parathion is an organophosphorous broad spectrum insecticide used in agriculture against foliar pests and the adult stage of root maggots. In some instances, resistance to parathion has developed and parathion is no longer effective. Available evidence suggests that parathion is not carcinogenic.

Pentachlorophenol (organic) (new)

The maximum acceptable concentration for pentachlorophenol in drinking water is 0.06 mg/L and the aesthetic objective is 0.03 mg/L. Pentachlorophenol, at concentrations above the aesthetic objective, will impart an unpleasant taste to the water. It is used extensively as a wood preservative. It is the most persistent chlorophenol. There are inadequate data to classify pentachlorophenol with respect to its potential carcinogenicity so additional safety factors have been incorporated into the derivation of the maximum acceptable concentration.

Pesticides

Pesticides, important in the evaluation of water quality, can be grouped by chemical composition. Chlorinated hydrocarbons and their derivatives tend to persist in the environment causing either direct or indirect health effects as a result of biological concentration in the food chain. Some chlorophenoxy herbicides and cholinesterase-inhibiting compounds, including organo-phosphorus chemicals and carbamates, have a high acute toxicity to mammals. These, however, hydrolyse rapidly in the aquatic environment to harmless or less harmful products.

pH (inorganic)

The operational guideline recommended in drinking water is to maintain a pH between 6.5 and 8.5. The principal objective in controlling pH is to produce a water that is neither corrosive or produces incrustation. At pH levels above 8.5, mineral incrustations and bitter tastes can occur. Corrosion is commonly associated with pH levels below 6.5 and elevated levels of certain undesirable chemical parameters may result from corrosion of specific types of pipe. With pH levels above 8.5, there is also a progressive decrease in the efficiency of chlorine disinfection and alum coagulation.

Phorate (pesticide) (new)

The interim maximum acceptable concentration for phorate in drinking water is 0.002 mg/L. Phorate is an organophosphorus insecticide used for control of sucking insects, larvae of the corn rootworm and leaf-eating beetles. Available evidence suggests that phorate is not carcinogenic.

Picloram (pesticide) (new)

The interim maximum acceptable concentration for picloram in drinking water is 0.19 mg/L. Picloram is a phenoxy alkanoic acid herbicide used for broadleaf weed and brush control on right-of-ways and roadsides. Picloram can be persistent in some soils for up to a year after application.

Polychlorinated Biphenyl (PCB) (organic)

The interim maximum acceptable concentration for polychlorinated biphenyl (PCB) in drinking water is 0.003 mg/L. PCBs are among the most ubiquitous and persistent pollutants in the global ecosystem. In the past, PCBs have been marketed extensively for a wide variety of purposes but their use in Canada is currently being phased out. There is some evidence which suggests that PCB may be carcinogenic, however, the data are insufficient to permit establishment of a maximum acceptable concentration of PCB in drinking water. The available information suggests that drinking water containing PCB at a concentration of 0.003 mg/L would not pose a health risk. Alternative supplies of drinking water should be considered if this limit is exceeded.

Prometryne (pesticide) (new)

The interim maximum acceptable concentration for prometryne in drinking water is 0.001 mg/L. Prometryne is a methylthiotriazine herbicide which is used to selectively control annual grasses and broadleaf weeds in crops and non-crops. It can be applied both as a pre-emergent and post-emergent herbicide.

Radium-226 (radiological)

The maximum acceptable concentration for Radium-226 in drinking water is 1 Bq/L. Radium-226 occurs naturally in the earth's crust as part of the uranium-238 decay chain. Environmental levels have increased in certain areas through the mining and milling of uranium. Radium-226, a by-product, may be carried into tailings ponds and dumps. Through releases, seepage and leaching, it has the potential to enter water supplies.

Selenium (inorganic)

The maximum acceptable concentration for selenium in drinking water is 0.01 mg/L. Selenium occurs naturally in waters at trace levels as a result of geochemical processes such as weathering of rocks and soil erosion. It is difficult to establish levels of selenium that can be considered toxic because of the complex interrelationships between selenium and dietary constituents such as protein, vitamin E, and other trace elements. Food is the main source of selenium intake other than occupational exposure. Selenium is an essential trace element in the human diet. Drinking water containing selenium at the maximum acceptable concentration of 0.01 mg/L would be the source of only 10 per cent of total selenium intake. The maximum acceptable concentration, therefore, is considered to provide a satisfactory factor of safety against known adverse effects.

Simazine (pesticides) (new)

The interim maximum acceptable concentration for simazine in drinking water is 0.01 mg/L. Simazine is a triazine herbicide which is used for pre-emergence weed control in annual row crops. It is registered for control of aquatic weeds in ponds. Simazine is the least soluble of all the triazine herbicides and is easily leached to grounwater where it may remain for years. Available evidence suggests that simazine is not carcinogenic.

Sodium (inorganic)

The aesthetic objective for sodium in drinking water is 200 mg/L. Sodium occurs naturally in the earth's crust and is not considered to be toxic. Consumption of sodium in excess of 10 grams per day by normal adults does not result in any apparent adverse health effects. In addition, the average intake of sodium from water is only a small fraction of that consumed in a normal diet. A maximum acceptable concentration for sodium in drinking water has, therefore, not been specified. Persons suffering from hypertension or congestive heart failure may require a sodium-restricted diet, in which case, the intake of sodium from drinking water could become significant. It is therefore recommended that the measurement of sodium levels be included in routine monitoring programs of water supplies. The Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L, so that this information may be disseminated to local physicians for their use with patients on sodium restricted diets.

Softening water by sodium-ion exchange will increase the sodium level in drinking water and may contribute a significant percentage to the daily sodium intake for a consumer on a sodium restricted diet. It is recommended that a separate unsoftened supply be retained for culinary and drinking purposes.

Strontium-90 (radiological)

The maximum acceptable concentration in drinking water for strontium-90 is 10 Bq/L. Strontium-90 is one of the long-lived, health-significant radionuclides found in both fallout from nuclear weapons tests and effluents from nuclear reactors.

Sulphate (inorganic)

The aesthetic objective for sulphate in drinking water is 500 mg/L. At levels above this concentration, sulphate can have a laxative effect, however, regular users adapt to high levels of sulphate in drinking water and problems are usually only experienced by transient and new consumers. The presence of sulphate in drinking water above 150 mg/L may result in noticeable taste. The taste threshold concentration, however, depends on the associated cations. High levels of sulphate may be associated with calcium, which may contribute to the formation of scale in boilers and heat exchangers. In addition, they may also contribute to the presence of hydrogen sulphide in some types of waters.

Sulphide (inorganic)

The aesthetic objective for sulphide in drinking water is 0.05 mg/L as H_2S. Although ingestion of large quantities of hydrogen sulphide gas can produce toxic effects on humans, it is unlikely that an individual would consume a harmful dose in drinking water because of the associated unpleasant taste and odour. Sulphide is also undesirable in water supplies because, in association with soluble iron, it produces black stains on laundered items and black deposits on pipes and fixtures. Sulphide is oxidized to sulphate in well-aerated waters and consequently sulphide levels in surface supplies are usually very low.

Taste (physical)

Taste and odour are intimately related, and consumers frequently mistake odours for tastes. In general, the sense of taste is most useful in detecting the ionic inorganic constituents of drinking water, whereas the sense of smell is most useful in detecting covalent organic constituents. Taste and odour problems constitute the largest category of consumer complaints. Changes in the taste of drinking water may indicate possible contamination of the raw water supply, treatment inadequacies, or contamination of the distribution system. A numerical limit for taste has not been specified because there is no objective method for the measurement of taste and there is considerable variation among consumers as to which tastes are acceptable. Water provided for public consumption should have an inoffensive taste.

Temephos (pesticide) (new)

The interim maximum acceptable concentration of temephos in drinking water is 0.28 mg/L. Temephos is an organophosphorus insecticide used as a larvicide for the control of mosquito and blackfly larvae. It is only slightly soluble in water. Available evidence suggests that temephos is not carcinogenic.

Temperature (physical)

It is desirable that the temperature of drinking water should not exceed 15°C. The palatability of water is enhanced by its coolness. Low water temperatures offer a number of other benefits. A temperature below 15°C will tend to reduce the growth of nuisance organisms and hence minimize associated taste, colour, odour and corrosion problems. In summer and fall, water temperature may increase in the distributed water due to the warming effect of the soil and/or as a result of higher tempera-

tures in the source water. Low temperature facilitates maintenance of a free chlorine residual by reducing the rates of reaction leading to hypochlorous acid removal. Although low temperature can decrease the efficiency of water treatment processes, this effect may be compensated for by altering the amounts of chemicals used in treatment. Low water temperature is not necessary to produce water of an acceptable quality.

Terbufos (pesticide) (new)

The interim maximum acceptable concentration of terbufos in drinking water is 0.001 mg/L. Terbufos is an organophosphorus insecticide used for soil dwelling insect control in corn. Available evidence suggests that terbufos is not carcinogenic.

2,3,4,6-Tetrachlorophenol (organic) (new)

The maximum acceptable concentration of 2,3,4,6-tetrachlorophenol in drinking water is 0.1 mg/L and the aesthetic objective is 0.001 mg/L. At levels above the aesthetic objective, it will impart an unpleasant taste to the water. 2,3,4,6-Tetrachlorophenol is used extensively, along with pentachlorophenol, to preserve wood. There are inadequate data to classify 2,3,4,6-tetrachlorophenol with respect to its potential carcinogenicity, so additional safety factors have been incorporated into the maximum acceptable concentration.

Toluene (organic) (new)

The aesthetic objective for toluene in drinking water is 0.024 mg/L. Toluene is used in the manufacture of benzene derivative medicines, dyes, paint solvents, coating gums, resins and rubber. It is commonly found in industrial effluents. At levels above 0.024 mg/L toluene will impart an unpleasant taste to the water.

Total Coliform (microbiological)

The coliform group of micro-organisms has been the most commonly used bacteriological indicator of water quality. The coliform group consists of all aerobic and facultatively anaerobic, gram-negative, oxidase-negative, non-spore forming, rod-shaped bacteria that ferment lactose in a broth medium with gas formation within 48 hours at 35°C. Most coliforms also produce the enzyme ß-D galactosidase. The group generally comprises the genera *Escherichia, Klebsiella, Enterobacter* and *Citrobacter*. Their presence in drinking water is indicative of inadequate disinfection.

MPN, MF and P/A are methods that may be used to detect coliform populations in drinking water. There are varying sensitivities associated with each method. Occasionally samples will produce positive results in one test and not with the others. In all cases where discrepancies are found, results from the method producing the positive result will be used in assessing the water quality.

Total Dissolved Solids (inorganic)

The aesthetic objective for total dissolved solids in drinking water is 500 mg/L. The term "total dissolved solids" (TDS) refers mainly to the inorganics dissolved in water. The principal constituents of TDS are chloride, sulphates, calcium, magnesium and bicarbonates. The effects of TDS on drinking water quality depend on the levels of the individual components. Excessive hardness, taste, mineral deposition, or corrosion are common properties of highly mineralized water. The palatability of drinking water with a TDS level less than 500 mg/L is generally considered to be good.

Triallate (pesticide) (new)

The maximum acceptable concentration for triallate in drinking water is 0.23 mg/L. Triallate is a thiocarbamate herbicide used for control of wild oats in grain crops, mustard and sugar beets. Available evidence suggests that triallate is not carcinogenic.

Trichloroethylene (organic) (new)

The maximum acceptable concentration for trichloroethylene in drinking water is 0.05 mg/L. Two thirds of trichloroethylene use is in metal degreasing operations and the other third is in tetrachloroethylene production. Trichloroethylene may be introduced into surface and ground water through industrial effluents. Although there is evidence to show that trichloroethylene is an animal carcinogen, there are insufficient data to comment on its human carcinogenicity.

2,4,6-Trichlorophenol (organic) (new)

The maximum acceptable concentration of 2,4,6-trichlorophenol in drinking water is 0.005 mg/L and the aesthetic objective is 0.002 mg/L. At levels above the aesthetic objective 2,4,6-trichlorophenol may impart an unpleasant taste to water. It is used in the manufacture of pesticides. The data is sufficient to classify 2,4,6-trichlorophenol

as an animal carcinogen but inadequate for human carcinogenicity. The maximum acceptable concentration has been set taking into account additional safety factors.

2,4,5-Trichlorophenoxy acetic acid (2,4,5-T) (pesticide)

The maximum acceptable concentration for 2,4,5-trichlorophenoxy acetic acid in drinking water is 0.28 mg/L and the aesthetic objective is 0.02 mg/L. 2,4,5-T is a phenoxy alkanoic acid herbicide that was once an important stem/foliage treatment for deciduous brush control on road sides and power lines. Of all the phenoxy alkanoic acid herbicides, 2,4,5-T is the most active on the greatest number of woody species. 2,4,5-T is no longer used in Ontario. The data is sufficient to classify 2,4,5-T as non-carcinogenic.

Trifluralin (pesticide) (new)

The interim maximum acceptable concentration for trifluralin in drinking water is 0.045 mg/L. Trifluralin is a dinitroaniline herbicide used for weed control in summer fallow and for controlling annual grasses in wheat, barley and rapeseed. Trifluralin is very insoluble in water.

Trihalomethanes (organic)

The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is currently under review. The MAC is based on the risk associated with chloroform, the THM most often present and generally found in the greatest concentration in drinking water. Trihalomethanes are the most widely occurring synthetic organics found in chlorinated drinking water. The four most commonly detected trihalomethanes in drinking water are chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. The principal source of trihalomethanes in drinking water results from the chemical interaction of chlorine with naturally occurring organics (precursors) in the raw water.

Tritium (radiological)

The maximum acceptable concentration for tritium in drinking water is currently under review. Tritium is produced naturally by the interactions of cosmic rays with nitrogen, oxygen and argon in the upper atmosphere. Nuclear explosions and nuclear energy production contribute man-made tritium.

Turbidity (physical)

The maximum acceptable concentration for turbidity in drinking water is 1 Nephelometric Turbidity Unit (NTU) for water entering the distribution system. An aesthetic objective of 5 NTU has been set for the point of consumption.

Turbidity in water is caused by the presence of suspended matter such as clay, silt, colloidal particles, plankton and other microscopic organisms. Turbidity can serve as a source of nutrients for micro-organisms and interfere with their enumeration. The adsorptive properties of suspended particles can lead to concentration of heavy metal ions and biocides in turbid waters. Turbidity has also been related to trihalomethane formation in chlorinated water. The most important health effect of turbidity is its interference with disinfection and with the maintenance of a chlorine residual. Viable coliform bacteria have been detected in waters with turbidities higher than 3.8 NTU even in the presence of free chlorine residuals of up to 0.5 mg/L and after a contact time in excess of 30 minutes. Outbreaks of disease traced to chlorinated water supplies have been associated with high turbidity.

Uranium (inorganic)

The maximum acceptable level of uranium in drinking water is 0.1 mg/L. Uranium is normally present in biological systems and aqueous media as the uranyl ion (UO_2^{2+}). Ingestion of large quantities of uranyl ion may result in damage to the kidneys. The uranyl ion may also be responsible for objectionable taste and colour in water, but the concentrations at which this happens are much higher than the concentrations which may cause kidney damage.

Vinyl Chloride (new) (organic)

The maximum acceptable concentration of vinyl chloride in drinking water is 0.002 mg/L. Vinyl chloride is a synthetic chemical with no known natural sources. It is classified as a human carcinogen.

Xylenes (new) (organic)

The aesthetic objective for total xylenes in drinking water is 0.3 mg/L. Above this concentration, xylenes will impart an unpleasant taste to the water. Xylenes consist of three isomers meta-xylene, ortho-xylene and para-xylene. Xylenes are used as industrial solvents and as an intermediate for dyes and organic synthesis. They are a component of household paints and paint cleaners.

Zinc (inorganic)

The aesthetic objective for zinc in drinking water is 5.0 mg/L. Water containing zinc at levels greater than 5.0 mg/L tends to be opalescent, develops a greasy film when boiled and imparts an undesirable astringent taste. The concentration of zinc may be considerably higher at the consumer's tap water because of the zinc in galvanized pipes. Corrosion control may minimize the amount of zinc in drinking water.

APPENDIX B

SUMMARY OF WATER DISINFECTION

Disinfection is the one step in water treatment specifically designed to destroy pathogenic organisms and thereby prevent waterborne diseases. The disinfection agents commonly used in water treatment today are chlorine and related compounds and ozone.

Chlorine

Chlorine was introduced as a disinfectant in water treatment in the early 1900's and has become the predominant method for water disinfection. Apart from its effectiveness as a germicide, chlorine offers other benefits such as colour reduction, taste and odour control, suppression of algal growth and precipitation of iron and manganese. In addition, it is easy to apply, measure, and control, provides a long-lasting residual and is relatively inexpensive. Chlorine, however, can react with naturally occurring organic matter to produce disinfection by-products such as trihalomethanes which need to be monitored.

The disinfecting efficiency of chlorine can be diminished by low temperature, high pH, turbidity, ammonia and organic nitrogen, as well as by high levels of iron, manganese and hydrogen sulphide. These parameters should, therefore, be determined to evaluate their effect on chlorine disinfection[1].

Maintenance of a Free Chlorine Residual

Maintenance of a free chlorine residual throughout a distribution system will protect the microbiological quality of the water throughout the system and provide a means of measuring the sanitary integrity of the distribution system. The disappearance of the chlorine residual, where one was formerly carried, provides an immediate indication of the entry of oxidizable matter into the system or of a malfunction in the treatment process. Since the chlorine residual test is quick and easy to perform, immediate corrective action can be taken. With conventional bacteriological testing, results are not available for at least 24 hours during which time the community may be at risk. It is recommended that a free chlorine residual be detected at all points in

[1] Chlorination of Potable Water Supplies, MOE Bulletin 65-W-4

the distribution system. Chlorine residual measurements should be taken at the same time bacteriological samples are taken. Excessive levels of free chlorine may result in taste and odour problems. In these cases, the MOEE shall determine the type and concentration of chlorine residual necessary to produce a microbiologically safe water.

Chlorine Dioxide

Chlorine dioxide offers a number of advantages over chlorine. Its germicidal potency is not affected by ammonia and pH within the usual range for drinking water; it effectively controls phenolic tastes and odours; and it is not known to form trihalomethanes. A potential problem with the use of chlorine dioxide may be the formation of chlorite ion which is reported to have detrimental, but poorly defined, health effects. Chlorine dioxide must be produced on-site.

Chloramines (combined chlorine)

Chloramines are produced by the reaction of aqueous chlorine and ammonia. Chloramines have less disinfecting power than ozone, free chlorine or chlorine dioxide for identical contact times, but they can be used when it is necessary to maintain a residual for long periods of time (eg, distribution systems). Chloramines assist in the control of certain taste and odour problems caused by chlorination and keep THM formation to a minimum. Because chloramines are slow-acting disinfectants and have poor performance on viruses and protozoan cysts and oocysts, they are seldom used as primary disinfectants.

Ozone

In some respects, ozone is a superior disinfectant to chlorine. It is unaffected by the pH or ammonia content of the water and it is more effective than chlorine against viruses, cysts, fungi and spores. Ozone, however, is unstable and as a result ozone residuals cannot be maintained for long periods of time. Chlorine must, therefore, be added after disinfection with ozone in order to provide a residual which can be maintained throughout the distribution system. Ozone must be produced on-site. Currently there are concerns about potential health effects of the by-products of ozonation. These are currently under review.

Ultra-violet

Ultra-violet radiation (UV), which is present in sunlight, kills bacteria, cysts, and viruses. Ultra-violet lamps concentrate UV onto a stream of water and the UV kills microbes. The raw water quality will greatly determine the effectiveness of the UV process. Turbidity or colour blocks UV penetration thus preventing the light from penetrating through to the microbes. Water containing protozoa parasites such as *Giardia lamblia* and *Entamoeba hystolitica* may need to be pre-filtered through a 5 micrometer pore size filter prior to disinfection with UV. Since UV treatment does not provide residual bactericidal action, chlorine or other disinfectant must be added after disinfection with UV in order to provide a residual which can be maintained throughout the distribution system.

GLOSSARY

Aerobic Bacteria - any bacterium that requires oxygen for growth and can grow under an air atmosphere (21% oxygen).

Aesthetic - aspects of drinking water quality (namely taste, odour, colour and clarity) that are perceivable by the senses.

Aggressive Water - having a tendency to corrode. Dissolved oxygen, pH, alkalinity, calcium, suspended solids, total salt concentration etc. all have different effects on the corrosion of different metals.

Algae - simple chlorophyll-bearing plants most of which are aquatic and microscopic in size.

Alkalinity - measure of a water's ability to neutralize acid; generally made up of bicarbonate and carbonate ions.

Alpha particle - a charged particle emitted from the nucleus of an atom and having a mass and charge identical to a helium nucleus. Gross alpha particle activity is the total radioactivity from alpha particle emission as inferred from measurements on a dry sample.

Anaerobic bacteria - any bacterium that does not use oxygen to obtain energy, cannot grow under an air atmosphere and for which oxygen is toxic.

Antiseptic - a substance used to destroy or prevent the growth of infectious microorganisms on or in the body.

Bacteria - a group of diverse and ubiquitous procaryotic single-celled organisms.

Becquerel (Bq) - unit of radioactivity which expresses the rate of disintegration of a radionuclide; one becquerel equals one nuclear transformation per second and corresponds to approximately 27 picocuries.

Beta particle - a charged particle emitted from the nucleus of an atom with the mass and charge of an electron. Gross beta particle activity is the total radioactivity resulting from beta particle emission as inferred from measurements on a dry sample.

Biocide - a substance that kills all living organisms, pathogenic or non-pathogenic.

Biofilm - microbial cells attach to pipe surfaces and multiply to form a film or slime layer on the pipe which can harbour and protect coliform bacteria from disinfectants.

Carcinogen - parameter for which the evidence from studies indicates that there is a causal relationship between exposure and occurrence of cancer, whether in animals or humans.

Cholinesterase - an esterase (enzyme) present in all body tissues which hydrolyses acetylcholine into choline and acetic acid. Acetylcholine affects nerve impulse transmissions therefore substances that impair the function of cholinesterase enzymes are neurotoxic.

Carbamate - a salt or ester of carbamic acid.

Coagulation - in water treatment, chemicals are added to combine with or entrap suspended and colloidal particles to form rapidly settling aggregates.

Colloid - particulate or insoluble material in a finely divided form that remains dispersed in a liquid for an extended time period.

Contamination - the introduction of materials which makes otherwise potable water unfit or less acceptable for use.

Corrosion - in the context of drinking water distribution, corrosion is the deterioration and leaching of metal from a pipe surface as a result of its reaction with the aquatic environment.

Cryptosporidium - a protozoan parasite that produces an environmentally stable oocyst, that is highly resistant to disinfection, but can be removed by effective treatment, which includes filtration.

Desiccant - a drying agent that will abstract water from a great many fluid materials.

Detoxification - the process of removing or neutralizing a poison.

Disinfection - effective elimination or destruction by chemical or physical processes of non-spore forming organisms capable of causing disease. Spore forming bacteria and parasitic cysts are usually resistant to traditional methods of disinfection.

Ectoparasite - a parasite that lives on the surface of the host body.

Filter - a porous media through which a liquid may be passed to effect removal of suspended materials.

Flocculation - the process by which suspended colloidal or very fine particles coalesce and agglomerate into well defined hydrated flocculents of sufficient size to set-

tle readily; the stirring of water after coagulant chemicals have been added to promote the formation of particles that will settle.

Fumigant - a chemical compound which acts in the gaseous state to destroy insects and their larvae and other pests.

Fungi - a group of diverse and widespread unicellular and multicellular eucaryotic microorganisms.

Gastrointestinal disturbances - disturbances related to the portion of the digestive system including the stomach, intestine, and all accessory organs.

Gamma Radiation - short wavelength electromagnetic radiation emitted from the atomic nucleus.

Giardia - small, flagellated, protozoan parasites that inhabit the small intestines of a variety of animals. Giardia is the most commonly reported intestinal parasite in North America causing nausea, diarrhoea, anorexia, an uneasiness in the upper intestine, malaise and perhaps low-grade fevers and chills. A well-managed water treatment system providing effective filtration and disinfection should control contamination by *Giardia*.

Gram-negative - referring to bacteria not holding the colour of the primary stain when treated by the Gram staining procedure.

Ground water - water located in the saturated zone of the earth's crust.

Herbicide - chemical agent that destroys or inhibits plant growth.

Humic Matter - major constituents of soil; the dissolved organic colouring material in water is almost totally made up of humic matter. Humic matter is divided into two classifications on the basis of their solubilities: humic and fulvic acids.

Hydroxybenzonitrile - an organic liquid with an almond colour.

Incrustation - deposition of a crust or hard coating on a surface.

Insecticide - any chemical or natural agent that kills insects.

Larvicide - an agent that kills larvae.

Macro-organism - aquatic organism that can be seen without the aid of a microscope, can include copepod, cladoceran, oligochaete, mollusca and aquatic insects.

Membrane Filter (MF) - a method for the enumeration of bacteria in water. A measured volume of water is filtered through a sterilized membrane which is then transferred to the surface of an appropriate agar medium and incubated. Upon incubation, retained bacteria give rise to visible colonies on the membrane surface.

Methaemoglobinaemia - a condition caused by the presence in the blood of methaemoglobin, an altered haemoglobin which is unable to transport oxygen.

Microorganism - a microscopic organism, including bacteria, protozoa, fungi, viruses and algae.

Miticide - an agent that kills mites.

Most Probable Number (MPN) - a method for statistically estimating the number of bacteria in water. It is not an actual count of the bacteria.

Nematode - member of the class Nematoda, the roundworms, some of which are parasites. Free-living nematodes are abundant in soil and water.

Non-point Source - discharge of pollutants which can not be traced back to a specific source, for example agricultural or urban run-off.

NTU (Nephelometric Turbidity Unit) - Unit of measure for turbidity in a water sample.

Occupational exposure - exposure to a parameter at the workplace.

Organochlorine - an organic compound containing one or more chlorine atoms.

Organophosphorus - an organic compound containing one or more phosphate groups.

Oxidase-positive - the presence, in bacteria, of the cytochrome c oxidase enzyme.

Oxidize - a process where the loss of electrons or hydrogen atoms or the combination with oxygen occurs.

Parameter - measurable or quantifiable characteristic or feature.

Parasite - an organism that lives on or in the body of another from which it obtains its nutrients.

Pathogen - an organism capable of eliciting disease symptoms in another organism.

Pediculicide - an agent used to destroy lice.

Pesticide - a parameter or mixture of parameters used to kill unwanted species of plants or animals.

pH - index of hydrogen ion activity, pH is defined as the negative logarithm of hydrogen ion concentration in moles per litre. A solution of pH 0 to less than 7 is acid, pH of 7 is neutral, pH from above 7 to 14 is alkaline.

Phenol - an organic chemical with a sharp burning taste, used to make a variety of other organic chemicals, resins, and as a solvent and chemical intermediate.

Picocurie - 10^{-12} curies (a curie is the unit of radioactivity contained in any quantity of material yielding 3.7×10^{-10} radioactive disintegrations per second).

Pollution (water) - causing or inducing objectionable conditions in any watercourse and affecting adversely the environment and use or uses to which the water thereof may be put.

Polynuclear hydrocarbon - organic chemical-hydrocarbon molecule with two or more nuclei, e.g. naphthalene.

Potable Water - water fit for human consumption.

Precipitate - to separate in solid particles from a liquid as the result of a chemical or physical change.

Presence/Absence (P/A) Test - a qualitative procedure used to determine the presence or absence of coliforms in water.

Protozoa - unicellular, non-photosynthetic, nucleated organisms, such as amoeba, ciliates and flagellates.

Raw Water - surface or ground water that is available as a source of drinking water but has not received any treatment.

Radioactive - capable of emitting radioactivity, the spontaneous nuclear disintegration with emission of corpuscular or electromagnetic radiation or both.

Radionuclide - a nuclide is a species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons and neutrons, and energy content; or alternatively by the atomic number, mass number, and atomic mass. Radionuclides are radioactive nuclides. To be considered as a distinct nuclide, the atom must be capable of existing for a measurable time.

Sanitary Survey - survey and analysis of the physical environment for the purpose of identifying existing and potential sources of health hazards and environmental contamination.

Scabicide - an agent lethal to itch mites.

Sedimentation - the process of deposition of sediment.

Spore - a reproductive unit lacking a preformed embryo that is capable of germinating directly to form a new individual. A resistant body formed by certain micro-organisms; a resistant resting cell; a primitive unicellular reproductive body.

Surface Water - water that rests upon the earth's surface.

TCU (True Colour Units) - the measurement of colour using the platinum cobalt scale. The colour of water resulting from parameters which are totally in solution not to be mistaken for apparent colour resulting from colloidal or suspended matter.

Toxicological - relating to the study of poisons, including their nature, effects, and detection, and methods of treatment.

Triazine - an organic heterocyclic compound containing a six-member ring formed from carbon and containing three nitrogen atoms.

Trivalent - having a valency of three.

Urea - the major end product of nitrogen excretion in mammals or the synthesis of industrial ammonia and carbon dioxide used as a source of non-protein nitrogen for ruminant livestock, and as a nitrogen fertilizer.

Virus - group of sub-microscopic agents that infect plants and animals, usually manifesting their presence by causing disease, and are unable to multiply outside the host tissues.

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